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THE NEW YORK RAPID TRANSIT RAILWAY power plant plans are approaching completion. There is to be one main power house and eight sub-power stations and the sites for these have already been purchased. The contracts for the engines and boilers have been awarded to the Allis-Chalmers Co., and to the Babcock & Wilcox Co. To the Allis-Chalmers Co., a contract was awarded for the construction of eight 5,500-HP. stationary engines. To the Babcock & Wilcox Co. an order was given for 48 boilers of 600 HP. each. The contracts were awarded with the stipulation attached that the engines and boilers be completed and shipped ready for use by Jan. 1, 1904. General Manager E. P. Bryan has also announced that a contract aggregating $1,500,000 will be let within the next few days for electrical apparatus, consisting of alternators, exciters, transformers and creators, to be used in the third-rail system. This is the system finally adopted by the company; so the subway road, using the side rail carrying the power and the contact shoe, will in that respect be very similar to what the Manhattan Elevated is to be after its electric plant is installed, and to what the new Boston Elevated is now. Bids for the power-house equipment have been submitted by the General Electric Co., of Schenectady, N. Y., the Westinghouse Co., and the Stanley Co., of Pittsfield, Mass. The Jan. 1, 1904, completion clause was stipulated in the call for these bids. The plans and specifications for the huge switchboard are now being made. As yet no bids for the construction of motors have been called for, nor is there immediate likelihood of such a call because the number of trains and consequently the number of motors have not yet been determined.

THE SEA-GOING SUCTION DREDGE for the Southwest Pass of the Mississippi River, which was described briefly in our issue of Sept. 5, will be built by Wm. R. Trigg & Co., of Richmond, Va. The pumping machinery for this dredge will be furnished by the Bucyrus Co., of South Milwaukee, Wis., and will consist of two 20-in. single suction centrifugal dredging pumps with direct compound condensing engines and the necessary incidental dredging outfit. This dredge will be the largest and most complete sea-going dredge which has yet been built for the U. S. Government. It is moveover the first sea-going hopper dredge which the Government has purchased with steel hull and twin screws. The dimensions of this hull will be, over all 271½ ft., molded beam 47½ ft., molded depth 23 ft. She will have a hopper capacity of about 2,000 cu. yds. The propelling engines will be compound condensing with cylinders 20 ins. and 40 × 30-in. stroke. In other respects the dredge will be a complete sea-going ship, with extensive cabin accommodations for officers and crew and with complete electric light outfit. She will steam at the rate of not less than 10 knots per hour.

THE NEW STEAMSHIP " LA SAVOIE," of the Compagnie Generale Transatlantique, arrived in New York Sept. 6, having made the run from Havre in six days eleven hours, the average speed being 19.36 knots. The vessel is practically a duplicate of "La Lorraine" of the same line, which began service last year, and a third ship of the same type, "La Provence," is under construction. "La Savoie" is 580 ft. long, and 60 ft. 2½ ins. beam, with a draft of 25 ft. 3 ins. Her total displacement is 15,300 tons. She is driven by two triple-expansion engines developing about 22,000 HP.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear-end collision on the Delaware, Lackawanna & Western Ry., near Elmira, N. Y., on Sept. 5. A freight train ran into the rear end of a work train loaded with laborers and demolished several of the rear cars of the work train. Altogetner 54 persons were injured, two of them seriously.

SCORES OF CASES OF TYPHOID FEVER have been traced to the use of water from an abandoned well at Hiram, O. The well was used, as a matter of convenience, on the occasion of two banquets at Hiram College, last June. Subsequently there occurred 23 cases of typhoid in Hiram and 37 elsewhere, all among the guests at the banquet. It is said that analyses have shown the water of the well to be contaminated, while that drawn from the public supply appeared to be perfectly safe.

RULES FOR THE SANITARY PROTECTION of the water supply of Concord, N. H., have been formulated and adopted by the state board of health of New Hampshire, under a legislative act passed in 1899. The action was taken in response to a petition from the water commissioners of Concord. The regulations prohibit in specific terms the pollution of Penacook Lake with sewage, garbage, dead animals or sawdust. The regulations in full may be found in the Manchester, N. H., "Union" for Aug. 24, 1901.

THE EFFECT OF THE CHICAGO DRAINAGE CANAL on the Illinois and Mississippi rivers is to be investigated simultaneously by the board of health of St. Louis and the trustees of the Chicago sanitary district. Each body will notify the other of the time and place of taking samples for analyses in order that duplicate samples may be examined for each board. The results of the tests, it is expected, will be used in the trial of the suit brought in behalf of the city of St. Louis to enjoin the operation of the drainage canal.

MUDDY WATER supplied to consumers by the Leavenworth (Kan.) Water Co. has resulted in a suit against the company by the Broadway Mfg. Co., of that city. It is claimed that the water supplied was so muddy that the boiler plant of the Broadway company had to be shut down for six days. The loss due to idleness of the plant is set at $75 per day, and $200 is claimed for damages to the boilers.

WATER METERS FOR CLEVELAND, O., are contemplated by an ordinance which recently passed the city council by a vote of 15 to 5.——The city of Fort Worth, Tex., has signed a contract for 2,500 water meters, mostly ⅝-in. in diameter.

THE SNOQUALMIE FALLS electric power plant at Snoqualmie Falls, Washington, about 44 miles from Tacoma and 32 miles from Seattle, is to be enlarged to meet the increasing demand for power in these cities. The original plant comprised four units, each consisting of a water-wheel direct-connected to a 2,000-HP. Westinghouse three-phase alternator. This installation, which is now generating and distributing 8,000 electrical horsepower, is to be more than doubled in capacity. At the same transmission voltage now employed, 30,000 volts, it is proposed to carry 12,000 HP. more into the cities above mentioned, making a total output of 20,000 electrical horse-power. The electrical machinery is to be wholly furnished by the Westinghouse Electric & Mfg. Co. The water-wheel contract will not be let for 60 days yet. If an impact wheel is used there will be a single wheel on each end of each generator shaft and each wheel will be driven by a single jet of water 14 ins. in diameter, the two jets combined being sufficient under the existing head of 270 ft. to give the requisite power. The two water-wheels and the generator between, will be built on a single hollow shaft of oil-tempered nickel steel. The present underground generating station, which is 200 ft. long, is to be lengthened out 150 ft. up stream to make room for the new installation. A new penstock is to be built which will carry 50% more water than the old one. The transmission line that is to parallel the old line will require 125 tons of aluminum wire, and the order for it has already been placed. At Tacoma a large sub-station is now being erected. The entire cost of these improvements will be in the neighborhood of $400,000. The work is to be vigorously prosecuted, and it is expected that the first of the new generators will be delivering current into Seattle and Tacoma within the next nine months. The generating machinery will consist of three 3,000-K-W. (4,000 HP.) rotating field generators of the two-bearing type, generating a three-phase current at 1,100 volts and 7,200 alternations. The speed is to be 100 r. p. m. Each generator will require an exciting current of 320 amperes approximately, at 125 volts. For exciting these three generators a 200-K-W. 8-pole direct-current generator of the two-bearing type is to be used. At 175 r. p. m. it is to deliver under normal load a current of 1,000 amperes at 125 volts. The current, which is generated at 1,100 volts is to be raised to a line potential of 30,000 volts by nine 1,000-K-W. oil-insulated water-cooled transformers. These are to be delta connected on both the primary and secondary sides. It is estimated that each transformer will weigh 11,000 lbs. and require 500 gallons of oil. The switchboard that is to be installed is to consist of 14 panels of white marble, and is to be of the special type that was furnished for the original installation. Instead of the Niagara type single-phase indicating wattmeter that is in use on the present switchboard a poly-phase long-scale indicating wattmeter is to be used. Where formerly a field-plug switch was used a double pole field switch is to be employed. The standard equipment of synchronizing lamps is to be replaced by a single pole plug switch mounted on the generating panel and connected to a synchroscope which will be mounted on the multipling panel. The increased capacity of the generators will necessitate placing three single pole main switches instead of one three-pole main switch. The circuit breakers, which are to be non-automatic, will be placed on an extension panel above the main instrument panel. The original plant was described in detail in Engineering News of Dec. 13, 1900.

THE GATHMANN GUN is shortly to be tested at Sandy Hook and targets made to represent a section of the battleship "Iowa" are now being made at the Brooklyn Navy Yard. The targets consist of a Krupp process armor plate 11½ ins. thick backed by 5 ins. of wood. The gun is designed to shoot a projectile charged with a high explosive. It is of 18-in. caliber, 44 ft. long and weighs 59 tons.

BY-PRODUCT COKE OVENS are to be built at Sparrows Point, Md., by the Maryland Steel Co. The coke product will be used to supply the blast furnaces and steel works of the company and the gas will be utilized, probably, for domestic supply in Baltimore and vicinity as has been done with the plant at Everett, Mass., near Boston. The plant it is said will comprise about 200 ovens.

THE DOMINION IRON & STEEL CO.'S annual report has been made public. The plant of this company is located at Sydney, Cape Breton, and was described in detail in our issue of July 25. In the report just issued President Whitney says:

The work of construction has been rapidly pushed the past year. Two of the furnaces are finished and are now producing iron of a very satisfactory quality. Investigations by drilling at Bell Island have revealed the fact that the quantity of ore actually there is more rather than less than the original estimate. There has been expended up to the present time, including the sum paid for the purchase and equipment of the Bell Island Ore property, the sum of $9,571,054.41.

In his report to the president, General Manager Moxham says:

We have been considerably disappointed in the delay in completing the plant; nevertheless two of our blast furnaces are now in operation and the other two so near completion that their operation will not be long delayed. The 400 coke ovens have been completed. The blooming mill has most of the machinery in place and everything needed to complete it is on the ground. The open-hearth plant is being energetically pushed by the contractors, and at the present rate of progress will be completed during the early fall. The piers and unloading plants are practically completed. We have gone far enough in the development of our ore mines af Wabana and in the working of our coke ovens and also in the development of our limestone to speak with certainty as to these three items. There only remains the cost of labor, and with a thoroughly modern design of plant and the very satisfactory way in which the new machinery has so far dropped into line in its practical working, I think we can rest assured that there is no doubt as to our labor costs.

FOUR-CYLINDER TANDEM COMPOUND LOCOMOTIVES are being used on the Northern Pacific Ry., there being 26 consolidation freight engines of this type, which were built at the Schenectady Works of the American Locomotive Co. Of these, 12 are for ordinary and 14 for mountain service. The high-pressure cylinders are placed forward, with the low-pressure cylinders reaching to the front drivers, and over the two cylinders is the valve chamber for two 12-in. piston valves, the chamber serving as an exhaust receiver for the high-pressure and a steam chest for the low-pressure cylinders. Starting valves enable live steam to be admitted to the low-pressure cylinders. The general dimensions of the mountain engines are as follows; the ordinary engines have 63-in. wheels, and weigh 198,000 lbs., with 2,907 sq. ft. of heating surface:

Driving wheels	4 ft. 7 ins.
Driving wheelbase	17 " 0 "
Weight on drivers	186,000 lbs.
Weight, total	210,000 "
Cylinders	15 × 34 and 28 × 34 ins.
Boiler, diameter	6 ft. 2¾ ins.
Working pressure	225 lbs.
Firebox	8 ft. 4 1-16 ins. × 6 ft. 3¼ ins.
Tubes	338; diameter 2 ins.; length 16 ft.
Heating surface, tubes	2,815 sq. ft.
Firebox (with arch tubes)	182 "
Total	2,997 "
Grate area	52½ "
Tender, weight, empty	47,000 lbs.
Coal capacity	10 tons.
Water capacity	5,500 gallons.

THE INTERNATIONAL GOOD-ROADS CONGRESS will be held in Buffalo, N. Y., on Sept. 16-21, 1901. The U. S. State, Postal and Agricultural Departments and other interests will co-operate in this Congress. Among other exhibits will be a special railway train equipped with modern road-making machinery, which will construct sections of road in Erie county, near Buffalo. This will be the first international good-roads congress ever held. The headquarters are at 726-28 Ellicott Square, Buffalo, N. Y. W. H. Moore is President and R. A. Richardson, Secretary.

THE LOOMIS WATER-GAS AND PRODUCER-GAS PROCESS.

In the issue of Engineering News for Oct. 11, 1890, we reprinted a paper, read by Mr. Burdett Loomis before the American Institute of Mining Engineers, describing his process for making water and producer gas. Since that date the process and apparatus have been considerably improved and a number of plants have been installed. Among the plants of recent construction is one built at the works of the Winchester Repeating Arms Co., New Haven, Conn. This plant was recently visited by a member of the editorial staff of this journal, and from the information obtained the following description has been prepared:

This plant has a capacity of about 2,000 HP. That is, if all the gas produced were to be used in gas engines it would furnish about that amount of power. Measuring its capacity in another way, it may be noted that the plant can consume a little more than a ton of coal per hour. At New Haven, the gas is mostly burned in heating and annealing furnaces, and only a small amount is used for power in a 50-HP. Struthers, Wells & Co.'s gas engine, which drives the machinery connected with the gas producers.

The striking and unique peculiarity of the Loomis process is that it is able to use soft or bituminous coal for the production of producer and water gas without the simultaneous production of tar or other harmful impurities in the gas. It is true that the process perfected by Dr. Mond in England makes producer gas from soft coal, but no attempt has been made to use his process in the manufacture of water gas.

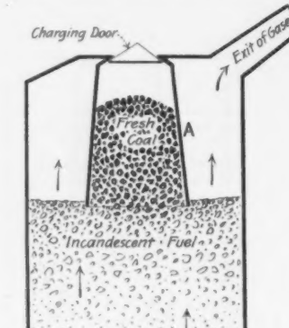


Fig. 1. Diagram of the Mond Gas-Producer.

In the ordinary and well-known process of manufacturing water gas, a bed of coke or anthracite coal is first brought to incandescence by driving a blast of air through it. When a high temperature has been attained the supply of air is shut off and steam is driven through. The highly-heated carbon decomposes the steam, with the formation of carbon monoxide and hydrogen, the chemical equation for the process being as follows:

$$H_2O + C = CO + 2H.$$

Since this reaction is endothermic, or heat-consuming, the fuel bed is rapidly cooled off and must be again blown up with the air blast. The blowing-up process, because of the depth of the fuel bed and the insufficient supply of air, is accompanied by the production of carbon monoxide. The heat latent in this combustible gas, as well as the sensible heat of the gases, is lost unless there is some use to which the blast gases can be applied. They may be used in regenerator stoves for heating the incoming blast of air, or may be passed through boilers for making the steam used in the production of the water gas. The best heat efficiency of this process, however, is never much above 60%.

In making gas by the water-gas process it would be impossible to use bituminous coal, since the tarry products driven off by the distillation of the coal would mingle with the gas and render the latter, without purification, unsuitable for most uses.

In the Mond process of making producer gas soft coal may be used. The Mond producer closely resembles the ordinary Taylor producer, except that it is so arranged that the fresh coal is not thrown directly onto the fuel bed, as in the latter, but is fed through a chute or funnel in such a way that the tarry vapors are distilled off in the heating up of the coal and compelled to pass through a hot bed of fuel and to mingle with the hot gases arising from it. The sketch shown in Fig. 1 represents diagrammatically a Mond producer. Without the funnel A it would differ in no respect from a Taylor producer, but that this funnel is very important when working with bituminous coal is easily seen. The fresh coal, as it slowly descends through the funnel, is brought to a high temperature, and the volatile and tarry products are driven off. The latter, in order to escape, however, must pass under the edge of the funnel and through the bed of incandescent fuel, in which they are decomposed to form less complex and more stable gases. As far as we are aware, no attempt has ever been made to use the Mond producer for making water gas.

The Loomis process may be best explained by reference to the drawing in Fig. 2. Two generators are always installed together, and are fired with fresh coal alternately. When making water gas the gases from the last-fired generator are passed through the second generator before going to the scrubbers and holders. When making producer gas the two generators are operated in parallel and the gases are drawn down through them by an exhauster. Hence, in both cases, the gases pass through an incandescent bed of fuel, and all tars or other heavy vapors are decomposed. The gases in both cases after leaving the generators are passed through the vertical boiler at Fig. 3.

The generators are of steel, lined with fire-brick, and are about 10 ft. in diameter and 15 ft. high. They are provided with fire-brick arched grates and ash-pits, from which flues lead to the boiler. Another flue connects the tops of the generators. There is a door at the top of each generator for firing and the admission of air, two cleaning doors above the grate and one below the grate opening into the ash-pit. There are four hydraulically operated valves, A, B, C and D, in the flues leading to and from the boiler. The use of these will be explained below in describing the method of operation.

In starting fires in the generators a layer of coke or coal about 5 ft. in depth is put in and ignited at the top, the exhauster creating a downward draft. When this has been ignited coal is added frequently until the top of the fuel bed is raised 8 ft. above the grate, where it is maintained. Air enters through the charging doors E and F, and is drawn down through the fresh coal and then through the hot fuel bed beneath. From the ash-pit the gases pass up through the boiler and then to the scrubber and producer-gas holder. During this operation the valves A, B and C and the doors E and F are open and the valve D is closed.

When the entire fuel bed has been brought to a state of incandescence, and it is desired to make water gas, the charging doors, E and F, and the valves B and C, are closed, and the valve D, leading to the water-gas holder, is opened. Steam is then turned into the ash-pit of generator No. 2, and in passing through the incandescent coal is decomposed, forming water gas. It then passes through the connecting flue to the top of generator No. 1, down through the fuel bed in that generator, and thence to the boiler. In making the next run of water gas the course is reversed; that is, the gas passes up through No. 1 and down through No. 2. A run of water gas lasts for about five minutes, at the end of which time the temperature of the fuel bed is considerably reduced.

By means of hydraulic connections a man on the operating floor is enabled to open and close the valves simultaneously and to by-pass the exhauster or throw it into action.

The water gas made by this process has a heating value of 300 to 350 B. T. U. per cubic foot. The richness of the producer gas depends to a large extent upon the way in which the generators are operated and varies between 90 and 120 B. T. U. per cubic foot. By introducing steam into the upper part of the generators while making producer gas the heating value of the gas can be considerably increased. For power and other purposes, the water and producer gas can be uniformly mixed by means of a proportional mixing valve.

The firing floor of the plant at New Haven is shown in Fig. 3. The plant is in duplicate and therefore comprises four generators and two boilers. The tops of the boilers, which are of about 80 HP. each, are seen in the photograph, together with the flues to the gas holders and their hydraulically-operated valves. The cast-iron flues are provided with diaphragm expansion joints. One of the charging doors, which is closed, may be seen at the left of the photograph. Fig. 4 shows the parts of the boiler and generators located below the operating floor. The gas delivered by the producers flows to two holders of 10,000 cu. ft. capacity each, located at the end of the building in which the producers are placed.

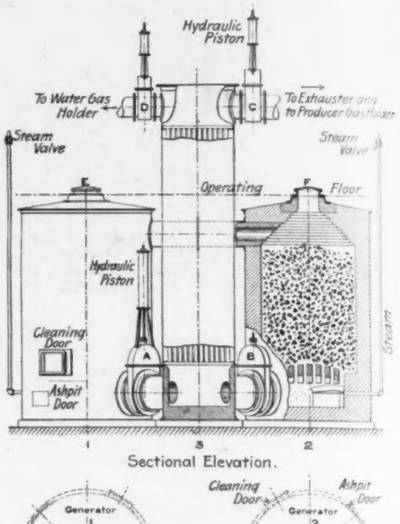


Fig. 2. Plan and Elevation of Loomis Gas-Producer Plant.

The boilers of this plant are connected with the boilers supplying steam to the steam engine plant of the factory by a pipe which takes care of any excess or deficiency of steam in the boilers of the producer plant. The water for operating the hydraulic valves is furnished by an automatic constant-pressure pump built by Henry R. Worthington, of New York city. The positive exhausters were furnished by the Connersville Blower Co., of Connersville, Ind. The coal used is George's Creek run of mine.

A plant similar to that just described has been in operation for some time at the Great Pilares Copper Mine, at Nacosari, in Sonora, Mexico. On account of the scarcity of coal in that region, wood is used for fuel.

The gas produced by the plant at the works of the Winchester Repeating Arms Co. has been found to be free of all impurities, except a small amount of soot, which collects in the scrubber. The latter is a large steel cylinder filled with loose coke, over which water is sprayed.

The plant which we have described was built by the Loomis-Pettibone Co., of 52 Broadway, New

York, to whose courtesy we are indebted for the drawings and photographs used in preparing the illustrations.

REPORT ON TRACK ELEVATION AT CINCINNATI, O.

The movement for the abolition of grade crossings at Cincinnati, O., was described in our issue of July 11, 1901, and we have since received a copy of the report made by the Committee on Track Elevation and Subways to the Board of Legislation. The report is dated Aug. 5, and an abstract is given herewith:

Your Committee on Track Elevation and Subways visited principally the cities of Chicago and Philadelphia. The object of the committee in making these trips was twofold: (1) To obtain an actual view of the viaducts and subways whereby grade crossings were abolished in the various cities and to study the methods of the construction thereof; (2), To obtain all the knowledge possible in regard to the various laws and ordinances whereby the abolition of grade crossings was accomplished, and to learn of the proportionate cost paid by the various railroads and municipalities.

CHICAGO.

The question of track elevation was first agitated in 1890 and the first actual work was done in the year 1892. The Illinois Central Ry. took the initiative in the matter, and after the passage of the first ordinance, on May 23, 1892, that road proceeded at once to elevate its tracks from 47th St. to 71st St., a distance of three miles. The work was pushed with rapidity, and was completed before the opening of the World's Fair, May 1, 1893, at an approximate cost of $2,000,000. Since that time the council of the city of Chicago has taken a thorough hold of the question of track elevation, and has passed ordinances from time to time, pursuant to which the railways have elevated their tracks as rapidly as circumstances would permit.

It will thus be seen that 61.40 miles of main track, affecting 343 crossings, have already been elevated by the various railways entering Chicago. This work was done at an approximate cost of $19,405,000, and was completed during the years 1892 to 1900, inclusive. In addition to this, ordinances have been passed providing for the elevation of 36.49 additional miles of main track, affecting 149 crossings, which elevation when completed will cost approximately $9,512,000.

LEGISLATION.—There appears to be no state legislation whatever affecting the city of Chicago on the subject of track elevation, and the entire matter seems to have been worked out by the municipal authorities, the council taking the principal part. The council has no power to compel railways to abolish grade crossings, and everything on that subject must be done by agreement with the railways.

PROPORTIONATE COST.—In Chicago the railways have paid the entire cost of elevating the tracks, and the city has paid the cost of all property necessarily appropriated for the elevation, also all direct or consequential damages to property as a result of the elevation. Where street railways have been affected, the companies were compelled to adjust their tracks to the new elevation at their own cost. All work is done under the supervision of the Commissioner of Public Works. If after a railway has elevated its tracks, the city lays out new streets or roads which intersect the railway, the city bears the entire expense of constructing the crossing, and the railway receives no damages for the crossing of its right of way.

PHILADELPHIA.

In Philadelphia the best example of the abolition of grade crossing is the Pennsylvania Ave. subway, extending from 13th to 30th Sts., a distance of nearly two miles, and through which run the tracks of the Philadelphia & Reading R. R. The construction of this subway was authorized by ordinance of councils, approved March 17, 1894, and the subway itself is a magnificent specimen of modern engineering.

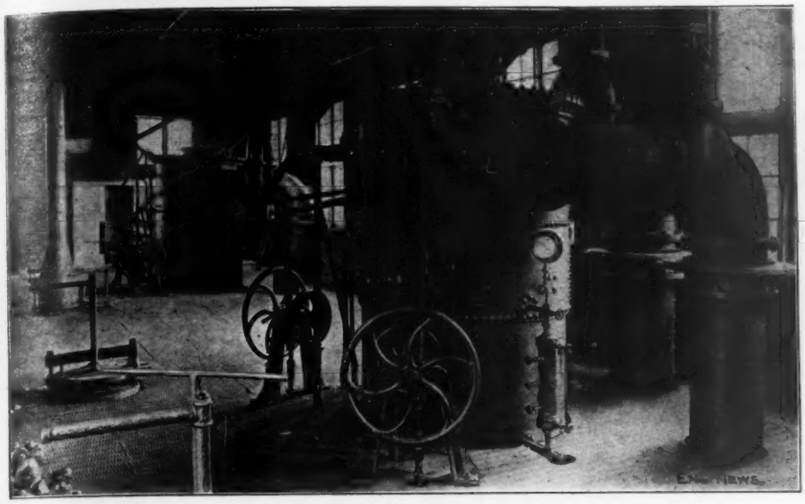


FIG. 3. LOOMIS GAS-PRODUCERS AT THE WORKS OF THE WINCHESTER REPEATING ARMS CO., NEW HAVEN, CONN.
Built by the Loomis-Pettibone Co., of 52 Broadway, New York City.

Another fine example of track elevation is that furnished by the Pennsylvania R. R. between Philadelphia and Holmesburg Junction. The distance between these two points is about 15 miles, and the tracks are elevated for the entire distance, there being not a single grade crossing between the two cities named. Other railroads that have elevated their tracks in Philadelphia are the Philadelphia & Trenton R. R., and the North Pennsylvania R. R. and connecting railways.

LEGISLATION.—The state of legislation with reference to track elevation in Philadelphia seems to be about the same as that in Chicago and Cincinnati. The councils seem to have taken the matter in hand, and ever since the year 1887 have been passing ordinances, in accordance with which the railways have been elevating their tracks with the results already mentioned.

Fig. 4. Parts of Gas Generators and Boiler Below Operating Floor.

PROPORTIONATE COST.—Millions of dollars have been spent in abolishing grade crossings in Philadelphia, and in most cases the railway company has paid one-half of the cost and the city the remaining half. In one case the railway company paid only one-third of the cost and the city two-thirds, but as a rule the cost is divided as above stated.

BUFFALO.

In Buffalo the abolition of grade crossings was accomplished through commissioners appointed by the New York Legislature, and having direct power to compel the elevation of tracks by writ of mandamus in case the railways refused. The railways paid the full amount of all work across their rights of way and two-thirds of all other work. The railways also paid two-thirds of the cost of property appropriated and one-half of the cost of property damaged, the city paying the balance in each case.

BOSTON.

In Boston, grade crossings are abolished by a special commission appointed for that purpose by the Supreme Court upon the petition of either the railway company interested or the alderman. This commission also apportions the cost, and the railway usually pays 65%, the State 25% and the city 10%. The cost of elevating tracks in this city up to date has reached $10,000,000.

CONCLUSION.

From what your committee has seen, it is unanimously of the opinion that the time is now ripe for promoting the elevation of railway tracks in Cincinnati.

As to the legislation on the question in Ohio, your committee wishes to say that there is an act passed by the general assembly on April 27, 1893. Your honorable board is therein given power to confer with the officials of the various railways, and to provide for the abolition of grade crossings according to the conditions of the act. Said law provides that the railroads shall pay at least 65% of the cost of abolishing grade crossings, and the city not more than 35%. Your committee is of the opinion that the street railway companies, which are directly affected, should also pay their proportionate share, and that whatever percentage is paid by said street railway companies should be deducted from the percentage to be paid by the city.

Your committee is also of the opinion that the provisions of said act are entirely sufficient, and that no further legislation is now needed. So soon as directed by your honorable board your committee stands ready to at once enter into negotiations with the officials of the various railways, and to push the question of track elevation so as to obtain the desired results at the earliest possible date.

Martin A. Brodbeck, Chas. H. Urban, H. W. Hamann, Edwin E. Kellogg, Thos. McDonough, Committee.

FOUR-TRACK TWO-TRUSS SWING BRIDGE; CHICAGO & WESTERN INDIANA R. R.

(With two-page plate.)

The Chicago & Western Indiana R. R. crosses the Chicago Drainage Canal at West 46th St., Chicago, by a four-track drawbridge of novel design. In the few cases where four-track swing bridges have hitherto been used there have almost invariably been three trusses, with two tracks on each side of the center truss. In the C. & W. I. R. R. bridge, however, there are only two trusses, with two tracks between them, the cantilever ends of the floor beams carrying the other two tracks outside of the trusses. This cantilever arrangement was proposed (by the same engineer) in the design prepared for an eight-track swing bridge over the Drainage Canal (Eng. News, April 7, 1898). The great advantages of this design are in the economy of construction, the diameter of the center pier being only 42 ft. 9 ins. under the coping, while that for the four-track three-truss bridge carrying the New York Central Ry. over the Harlem River is about 60 ft. diameter. The span is thereby increased about 20 ft. in order to obtain the same width of clear waterway.

The bridge is 334 ft. 4½ ins. long, c. to c. of end bearings, and crosses the channel at an angle of 68°. The total weight of iron and steel in the structure is 1,346 tons, exclusive of the operating machinery, which is not yet installed. Fig. 1 is a general view of the bridge, and Fig. 2 an end view, but at the time these views were taken only the two center tracks had been laid. The bridge was opened to traffic on Nov. 12, 1900.

SUBSTRUCTURE.—The substructure and center pier consist of Portland cement concrete and Bedford stone masonry, resting on a very hard clay foundation. The base of the foundation of the pier is 9 ft. below the bed of the channel, and the maximum load is about 5,000 lbs. per sq. ft. The pier is octagonal, 43 ft. 9 ins. diameter over the coping, and is peculiar in that it has only earth filling inside the masonry shell. The shell is 7 ft. thick, built in courses of 18 to 24 ins. in height, leaving a central well 28 ft. 9 ins. diameter. The center pin for the turntable is carried by two pairs of plate girders resting on a bench of the masonry, the tops of the girders being flush with

the coping. These girders are shown in the section of the pier, Fig. 3, and also in the general plan, Fig. 4.

TRUSSES.—The superstructure has two through trusses, the general design of which is similar to that of the bridges over the same canal described in our issue of Dec. 2, 1897, but the construction is much heavier on account of the double loading. This is shown by the strain sheet and composition diagram in Fig. 4, which illustration also shows the lateral bracing and portals. Each truss has a center panel of 24 ft. 5⅝ ins., over the pier, and 14 panels of 22 ft. 1¾ ins. Riveted connections

assumed to be 3 ins. Live load, (3) continuous girder of four supports, with equal moments over center supports; 4,980 lbs. per lin. ft. for entire length of bridge on the adjacent inside track, 4,200 lbs. on the adjacent outside track and the distant inside track, with no load on the distant outside track; (4) simple span; 4,980 lbs. per ft., moving from end to tower (L-0 to L-7) on the adjacent inside track, and 4,200 lbs. on the adjacent outside track and distant inside track, with no load on the distant outside track. For calculating the sections of members, conditions (1) and (4) were combined; while (2) and (3) were also combined.

These are mounted on the rollers in the manner shown in Fig. 8. Each roller has a 1½ in. shaft about 4 ft. long, the inner end of which is carried by a radial angle riveted at one end to the center plate and at the other end to the angle iron ring inside the roller circle. Outside the rollers is a 6-in. channel iron ring. The rollers run on a cast-steel track plate on the cast-iron base upon the pier; brackets on this base casting carry the operating rack. The rack has a pitch diameter of 41 ft. 1⅜ ins., with teeth 8 ins. deep and 3⅞ ins. pitch. The cast-iron center is carried by two pairs of plate girders across the pier and flush

FIG. 1. GENERAL VIEW OF FOUR-TRACK TWO-TRUSS SWING BRIDGE.

FIG. 2. END VIEW OF FOUR-TRACK TWO-TRUSS SWING BRIDGE.

are used for all compression members. The depth is 32 ft. at the ends and 56 ft. over the pier. The top diagonal bracing is of square rods, and the bottom diagonal bracing of angle irons. Portal bracing is introduced between the tower posts, the outer end posts and intermediate end posts, with sway bracing at all other panel points. The hip joint (U-5) is peculiar in that no less than 13 eyebars center at this joint. From the detail drawing, Fig. 5, it will be seen that the five bars from the central tower, and the four diagonal bars of the truss panel, all take hold of the main 10-in. pin at the hip. The four vertical bars are suspended from an 8-in. pin carried by gusset plates riveted to the chord and post.

FLOOR SYSTEM.—The total width of the bridge is 57 ft. 4 ins. over the angle irons of the guard timbers placed just outside the floor to prevent injury from vessels striking the structure. The trusses are 29 ft. 6 ins. apart, c. to c., and between them are two tracks 13 ft., c. to c. At each panel point is a plate girder floor beam, riveted to the posts above the bottom chord, these girders being 6 ft. deep, diminishing to 5 ft. at the cantilever ends. Between these floor beams are four pairs of plate girder stringers, 3 ft. 10 ins. deep, those of each pair being spaced 7 ft. apart. Upon these are laid 10-ft. yellow pine ties, 8 × 8 ins., spaced 14 ins., c. to c. No inside guard rails are used, but there are outside guard timbers, 6 × 8 ins., boxed out ½-in. for the ties and bolted to every third tie with a ¾-in. hook bolt. One of the intermediate floor beams is shown in the cross-section, Fig. 6. At the outer ends of the cantilever beams are riveted two lines of 12-in. channels, to each of which is bolted a guard timber having its face beveled and protected with an angle iron 6 × 6 ins.

For splicing the top chords of the floor beams at the gap left for the posts, heavy plates are riveted to the chord on each side of the gap; these plates are 38½ ins. wide, and carry tie-angles ¾ × 6 × 8 ins. which bridge the gap and fit against the posts. It will be evident that very heavy connections are required at these points, as the floor beams are cantilevers beyond the posts. The bottom chord is stiffened under the post by a chord cover plate and two angles 6 × 6 ins., with a ½-in. plate riveted between them, forming a T-section. The construction is rather notable for the use of these large angle irons, 8 × 6 ins., not only for the tie angles at posts, but also for the lower chords of the floor beams. These angles have triple rows of rivets in the 8-in. legs.

LOADING.—The conditions of loading for the trusses are as follows: Dead load, 7,800 lbs. per lin. ft. of bridge; (1) ends touching, and (2) ends raised half the total deflection, this latter being

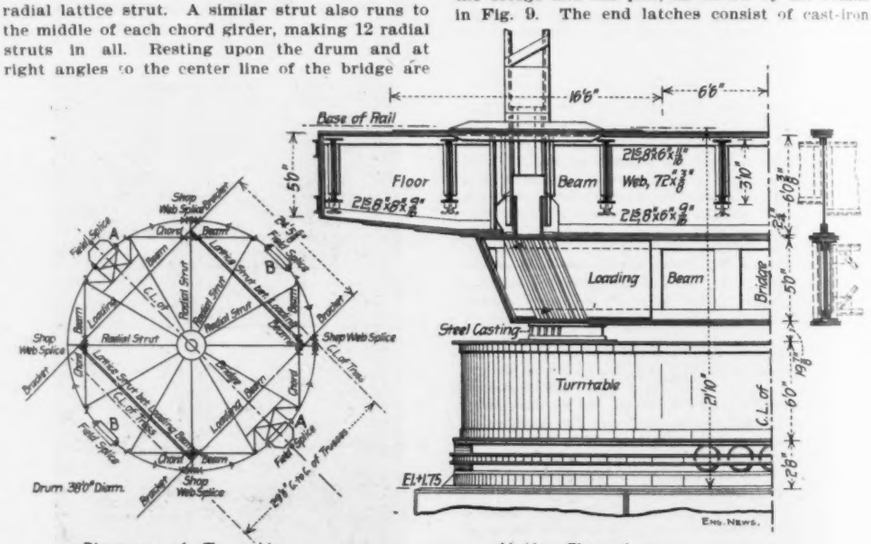
The stresses in the longitudinal bracing of the center panel (or tower) were calculated to transfer a shear across this panel, due to an unbalanced load of 15,000 lbs. suspended from one end of the truss. The maximum moments and end shear of the floor beams are as follows:

	Max. moment ft.-lbs.	Max. end shear lbs.
End floor beams	1,275,000	146,600
End floor-beam brackets	1,275,000	154,900
Intermed. floor beams	1,442,000	185,100
Intermed. floor-beam brackets	1,442,000	177,700

TURNTABLE.—The drum of the turntable is a circular plate girder 38 ft. diameter and 6 ft. deep, with a single web plate. Inside this are four double-web chord girders, forming, with the drum, an octagonal frame, at each angle of which is a radial lattice strut. A similar strut also runs to the middle of each chord girder, making 12 radial struts in all. Resting upon the drum and at right angles to the center line of the bridge are

with the coping, as already described. The turntable is entirely rim bearing.

MACHINERY.—Like all the other bridges on the Drainage Canal, this bridge has been erected without its operating machinery, and this will only be installed at some future time, when the canal is opened for navigation. The end lifts are cast-steel wedges under the bottom chords. Each wedge is connected by two eyebars to a 12-in. cast-steel pinion mounted in journals under the chord. A horizontal rack gearing with the pinion forms the extension of a piston rod which passes through two tandem air cylinders 16 × 27½ ins., designed to use air at a pressure of 70 lbs. per sq. in. The wedges slide between shoes attached to the bridge and the pier, as shown by the details in Fig. 9. The end latches consist of cast-iron


Base of Rail
Floor
Beam
Loading
Beam
Bridge
Steel Casting
Turntable
Drum 380" Diam.
Shop Web Splice
Field Splice
Radial Strut
Lattice Strut and Loading Beam
C.L. of Ties
C.L. of Truss
Chord
Tracker
Bracket
Shop Web Splice
Shop Web Splice Bracket
Floor Beam
Loading Beam
Bracing
Lattice Strut and Floor Beam
Shop Web Splice
Field Splice
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Radial Strut
Lattice Strut and Loading Beam
C.L. of Ties
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Floor Beam
Field Splice
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Bracket
Field Splice
Chord
Shop Web Splice

of the Chicago & Western Indiana R. R. We are indebted to Mr. Hughes for photographs, blue prints, etc. The contracts for both substructure and superstructure were awarded to the Toledo Bridge Co., of Toledo, O., in May, 1899, and the contract for the substructure was afterwards sublet to the McArthur Bros. Co., of Chicago. The cost of the superstructure was $131,393, or about $97.50 per ton, including the floor, the work being let at a time when the price of steel was extremely high. The cost of the substructure was $51,353, making the total cost of the bridge $182,746. The unit prices for substructure were as follows: Excavation (average), 51 cts. per cu. yd.; Portland cement concrete, $7.30 per cu. yd.; stone masonry, $13.35 per cu. yd. In construction these unit prices were considerably increased on account of working overtime, but the totals given above represent the actual cost of the structure.

FIG. 1. VIEW SHOWING THE "CUT BANKS" OF THE MISSOURI RIVER, BENTON CUT, GREAT NORTHERN RY.

THE CONSTRUCTION OF THE BENTON CUT ON THE GREAT NORTHERN RAILWAY, MONTANA.

By Geo. H. Herrold.*

In making a change in alinement to eliminate the 2.2% grade up Government Coulee to the divide between the valleys of the Teton and Missouri Rivers, some heavy work was done by the Great Northern Railway on its Great Falls line during the past year. The new grade enters the valley of the Missouri through a tunnel 540 ft. in length near the junction of the Teton and Marias Rivers, and following up the valley of that stream along the west wall, enters the town of Fort Benton through a tunnel 460 ft. in length on a 5° curve. About two miles south of the town the line leaves the river. Here the road bed is 37 ft. below the level of the bench, and a thorough cut on a 0.6% grade brings it out on the plains again a mile distant. Connection with the old track is made about six miles west of this point at Tunis siding.

The most interesting portion of this work came under the supervision of the writer. Just south and west of Benton the line crosses a number of deep coulees, and then parallels the river along what are called the "cut banks," which here rise to a height of 300 to 340 ft. The road bed is 230 ft. above the river, which leaves a maximum cut of 110 ft. A large part of the excavation was earth, with occasional layers of sand and gravel, while the bottom of the cut was a hard clay, which made a good support for the high slope taken down one on one. The underlying formation is shale, which stands at an angle of about 10° with the vertical, the river being at the foot. This cliff has a height of 150 ft., its continuity being broken by narrow ravines. The view, Fig. 1, and the profile, Fig. 2, give a fair idea of the physical features.

The line was located along the cliff, so that the plane of a 1½ on 1 slope from the road bed would cut the river bank at about high water mark. The work was cross-sectioned. Parallel lines were run on each side of the center line to work from, and cross-sections taken from 7 to 25 ft. apart, according to the ground. The men were supported by ropes while working, as a misstep meant a long slide, and perhaps a vertical drop from quite a height into the river.

The contractors began work in February, blasting down the points and dumping through traps where the ground permitted the use of teams. A road was then built along the face of the cliff by casting and wheelbarrow work, track was laid, and yard cars and a crew of shovelers were put in, Fig. 3. Considerable difficulty was experienced in keeping men on account of the dust. The prevailing wind, sweeping down the river, became entangled in the narrow ravines and carried the dust from the falling earth back into the faces of the laborers. The place became known as the "flour mill," and the "Blanket Stiffs" touring the country diligently in search of work gave it a wide berth.

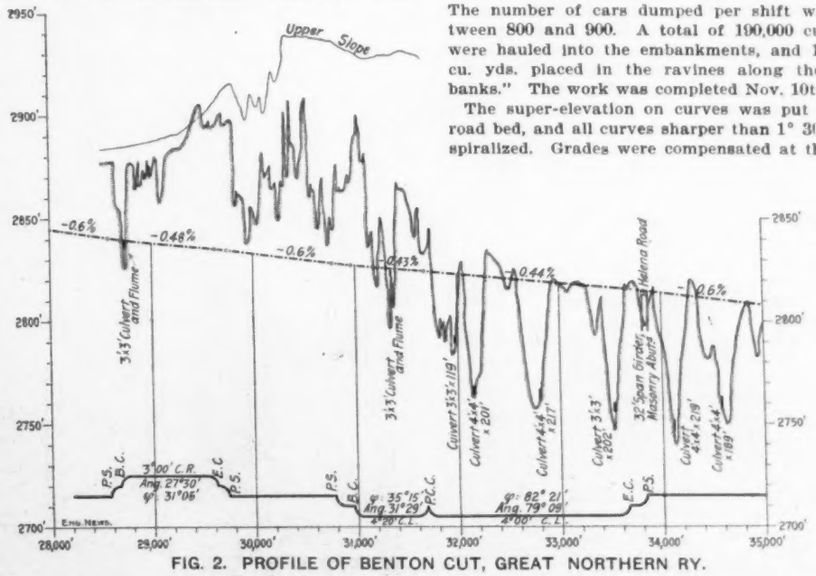


FIG. 2. PROFILE OF BENTON CUT, GREAT NORTHERN RY.

In the latter part of May the contractors put in a steam shovel with a 1½ cu. yd. dipper, increased the size of their cars to 1½ cu. yds., and began working two 10-hour shifts. Fig. 4 shows the shovel at work. Double track was used, and by keeping the switch above the shovel the empties were run down to it on the loading track. This allowed a continuous movement of cars. The cuts made by the shovel were kept on a grade to give a momentum to the loaded trains running to the embankment, and the track was kept true to line and grade to permit of high speed. In this way a great bulk of the material was moved by gravity, the empty trains of nine or ten cars being hauled back by one team of horses. The embankments were 250 to 600 ft. long, and the four deepest range from 60 to 75 ft. in depth. Temporary timber culverts built of 12-in. stuff were placed in each, it being impracticable to transport cast-iron pipe over the ground before construction. The culvert pits came in the shale and the culverts showed but very little settlement after the banks were over them.

Framed trestles were built in each coulee to facilitate the filling. The trains were dumped in the center, directly over the culvert, this method preventing a transverse slope from forming, with the resulting danger of shoving the culvert. When the dump reached the top of the structure the caps and stringers were removed and taken to the next trestle, while the track now resting on the new-made bank was lifted gradually as the dumping continued until the embankment was brought to sub-grade. The slope of the trestles was 1 in 90, and the receiving end was 1 ft. below sub-grade, the ground being cut down to fit this for about a train length back. This gave an easy start for loaded trains that for any reason had to stop before running onto the timber work. The banks were cross-sectioned for a 16-ft. bed and 1½ to 1 slope, but were built 25 to 35 ft. wide, and then shouldered 20 ft., the remaining width being sloped at about 10 to 1 to the side slope for drainage. This gives sufficient width upon which to build to grade again, after a vertical shrinkage of 1 ft. in 20, without any filling on the slopes.

In running through the last time the shovel took out a cut 20 ft. wide (the width of the road bed) with vertical walls. This left a bench about 5 ft. wide from the edge of the shovel cut to the slope upon which the cars were operated. The excavation was made below grade and then filled in by breaking down this bench after the shovel was taken out. Fig. 5 shows the completed cut.

The limit of the shovel was never reached; that is, the limiting factors in the work were the dumping of the cars and the return of the empties. The time required to load one train of cars and spot the first car of the second train was two minutes. The number of cars dumped per shift was between 800 and 900. A total of 190,000 cu. yds were hauled into the embankments, and 150,000 cu. yds. placed in the ravines along the "cut banks." The work was completed Nov. 10th.

The super-elevation on curves was put in the road bed, and all curves sharper than 1° 30′ were spiralized. Grades were compensated at the rate of 0.04′ per degree. The maximum grade was 0.6%.

The contract for the entire change of line was let to A. Guthrie & Co., of St. Paul, Minn.; McDougall & Yale, of Milwaukee, Wis., being the subcontractors for the work of which this article speaks. The work came under the engineering department of the Montana Central Ry., Mr. J. C. Patterson being the resident engineer, and Mr. P. E. Thian being the engineer in charge of the entire change. The writer was the Resident Engineer on Construction.

*Great Western Railway, St. Paul, Minn.

THE COST OF RUNNING TRAINS AT HIGH SPEED.

By John G. Crawford.*

This article is based on the results of tests made on the Chicago, Burlington & Quincy Railroad, during July, 1900, under the direction of Mr. Max H. Wickhorst, Engineer of Tests. The writer, together with Mr. Geo. W. Ristine, Jr., at that time students of Cornell University, assisted in the tests and prepared their graduating thesis from the results. The report of the committee on "Cost of Running Trains at High Speed," presented at the recent meeting of the American Railway Master Mechanics' Association (Eng. News, June 27, 1901), included the results of these tests as furnished by Mr. F. A. Delano, Superintendent of Motive Power.

Fig. 3. View Showing Wheelbarrow and Shovel Work, Preparatory to Constructing Dump Car Tracks, Benton Cut, Great Northern Ry.

The tests consisted of five runs from Chicago, Ill., to Burlington, Ia., a distance of 206 miles. Three runs were made on fast mail train No. 15, and two on a special train of the same make-up, run at half the speed and carrying no lading. The fast mail train leaves Chicago at 9.30 p. m. and arrives at Burlington at 1.18 a. m., making an average schedule running speed of 55 miles per hour. The special train left Chicago at about 8.30 a. m. and its schedule was made out by doubling the time between the stations and at stops. The fast mail train makes two crossing stops within the city limits of Chicago and station stops at Mendota and Galesburg, 82.8 miles and 162.5 miles from Chicago, respectively. The special train was to have made only these stops, but was blocked several times.

Train No. 15 was hauled by engine No. 1590. This engine is of the Columbia type, with cylinders 18 × 26 ins., and total weight of 128,700 lbs. The special train used engine No. 1121, American type, cylinders 17 × 24 ins., and total weight 89,700 lbs. The object of using different engines was to have an engine suited to the service.

The trains consisted of the dynamometer car, two baggage cars and two mail cars. The average weight of the mail trains was 180 tons, and that of the special train 160 tons. The records taken were coal and water consumption, speed, draw-bar pull and steam pressures.

In studying the results of these tests the following items should be taken into consideration:

(1) The weather during the tests was most favorable for easy running and low cost of operation; light winds, temperature about 70°, and rain for only 40 miles out of the 1,000 miles of running.

(2) The special trains were required to make an average of four stops more than scheduled on account of being blocked. The mail train was required to slow down to about 15 miles per hour on new track and the special made a number of slow-downs. These additional stops and slow-downs mean additional fuel and water consumption.

(3) Engine No. 1121, which was used on the special train, is somewhat larger than would be required on a train of this character, and was in consequence under-loaded.

(4) The coal burned per square foot of grate surface per hour was in the case of the fast mail train 109.1 lbs., as against 49.1 lbs. in the case of the special train. The coal used was the best grade of screened lump Illinois coal, known as Streator No. 1.

(5) If doubling the speed of a train doubles the resistance at the draw-bar, then the horse-power at the draw-bar is increased four times and the work done on the train in hauling it a given distance, together with the horse-power hours, are doubled.

Results of Dynamometer Tests of Fast Mail Train No. 15 and Special Train.

	Train No. 15.	Special train.
Schedule running speed, miles per hr.	54.88	27.44
Actual running speed, miles per hour..	56.24	28.69
Weight of lading, tons	16.7	0.0
Total, of train, etc., tons	263.4	219.7
Excluding locomtv and tendr, tons.	179.8	159.85
Coal used, lbs.	12,690	6,149
Per ton-mile, lbs.	0.3342	0.1869
Per sq. ft. of grate surface, per hr.	109.1	49.1
Per sq ft. of heating surf, per hr.	2.37	0.805
Average boiler pressure, lbs.	184.0	149.0
Water evaporated, lbs	63,770	38,525
Used per ton-mile, lbs.	1.7233	1.1710
Average developed HP., at draw-bar.	325.0	64.8
Developed HP. hrs. at draw-bar..	1,192	464.0
Draw-bar pull, lbs.	2,164	844.0
Per ton hauled, lbs.	12.1	5.3
Steam used, draw-bar, HP. hr., lbs.	53.3	83.0
Water evaporated per lb of coal.	5.03	6.27
Water evaporated*, per lb. of coal.	6.02	7.46

*From and at 212° F.

For comparison the following table is given; the fast train being the standard:

	Train No. 15.	Special train.
Speed	100%	51.0%
Draw-bar pull per ton	100%	43.9%
Water per ton-mile.	100%	68.0%
Coal per ton-mile	100%	55.9%
Horsepower at draw-bar	100%	19.9%
Work done at draw-bar.	100%	39.0%
Horsepower hours at draw-bar	100%	39.0%
Steam per draw-bar HP. hr.	100%	156.0%

The results of these tests show that the draw-bar pull per ton was more than doubled by doubling the speed, and that the water consumption per ton-mile was increased only 50%, while the coal consumption per ton-mile was nearly doubled. The draw-bar pull per ton is computed from the average draw-bar pull, and is not corrected for grades, curves or stops.

The increase of only 50% in water consumption per ton-mile when the speed is increased from 30 to 60 miles per hour is due to the greater efficiency at the draw-bar of the engine used on the fast mail train. The engine used on the special train was under-loaded and consequently less efficient. As the engine on the fast train overcomes a greater head resistance than the one on the slow train, this fact should tend to make the fast mail engine less efficient at the draw-bar.

The greater efficiency of boiler and grate in the case of the engine hauling the slow train is due to the lower rate of combustion employed.

There being only two points showing the relation of speed to coal and water consumption, one the result of tests at 30 miles per hour, the other the result of tests at 60 miles per hour, one would hardly be justified in stating a general law of the effect of speed on coal and water consumption. The tests tend to show that increasing the speed from 30 to 60 miles per hour doubles coal consumption and increases the water consumption 50%. Taking into consideration all things influencing the results, it seems more than likely that had the engine on the slow train been more nearly adapted to the service that the water consumption, and consequently the coal consumption, would have been less. Hence, a justifiable conclusion is that increasing the speed of a four or five-car train from 30 to 60 miles per hour more than doubles the coal and water consumption, probably an increase of not exceeding 120% for water and 175% for coal. The above percentages were figured from the draw-bar HP. hours, taking into consideration weights of train and assuming a water rate for the special engine as low as that for the fast mail engine, also taking account of the greater efficiency of boiler and grate in the case of the engine hauling the slow train.

Fig. 4. View Showing Steam Shovel Work, Benton Cut, Great Northern Ry.

FIG. 5. VIEW SHOWING PORTION OF BENTON CUT COMPLETED, GREAT NORTHERN RY.

*4131 Drexel Boulevard, Chicago, Ill.

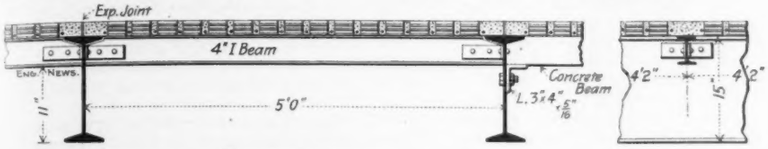
EIGHT-COUPLED FREIGHT LOCOMOTIVES are becoming more general in England, where for many years the standard freight engine has been a six-wheeled engine, with all wheels coupled. The newer and more powerful engines have all the eight wheels coupled, no trucks

being used. The Caledonian Ry., of Scotland, which is one of the pioneer roads to use freight cars of 30 and 50 tons capacity, and to equip its freight cars with the Westinghouse brake, is putting in service a number of the eight-coupled engines, which are peculiar in having the two middle pairs of wheels close together, but spaced far apart from the leading and trailing wheels. The cylinders are inside the frames, 21 × 26 ins.; and the wheels are 4 ft. 6 ins. diameter. The boiler is of the straight-top pattern, with nearly 2,500 sq. ft. of heating surface. The engine, with its six-wheel tender, weighs about 100 tons.

The designs for the new engines were made by Mr. McIntosh, the Locomotive Superintendent. The Northeastern Ry. is also building at its own shops 20 eight-coupled freight engines, weighing about 90 tons, and designed by the Locomotive Superintendent, Mr. W. Worsdell. These have driving wheels 4 ft. 7½ ins. diameter and cylinders 20 × 26 ins.; 10 will have slide valves and the other 10 will have piston valves. These engines, like those of the Caledonian Ry., are being built specially with a view to increased train loads, although only a few years ago English papers and railway men were explaining that more powerful engines were not needed and that increased train loads were neither practicable nor desirable under the traffic conditions of English railways.

TEST OF A STEEL-CONCRETE SIDEWALK VAULT-LIGHT SLAB.

We illustrate in the accompanying cuts the methods and results of a strength test of a sidewalk vault-light slab of concrete and twisted steel construction, which was recently undertaken at the instance of Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., Chief Engineer of the New York Rapid Transit Railway. The slab tested was built by Tucker & Vinton, Inc., of New York city, and, its construction, it is stated, conformed in all particulars to the vault lights manufactured by them for commercial purposes. Figs. 1 and 2 show the details of this system of vault-light construction quite clearly, but do not show the actual construction of the slab tested. In this slab two 12-in. I-beams, 13½ ft. long, was spaced 5 ft. apart c. to c. and supported on blocking. Between these two beams were set three 5-in. I-beams, with their tops 2 ins. below the top flange of the main beams. The vault-light slab rested on this framework platform but was not in any way connected to it. This slab had ribs on its under surface to act as fillers and give the slab a bearing on the 5-in. beams, but was everywhere else only 2 ins. thick.



Transverse Section. Long. Section.

FIG. 1. SECTIONS SHOWING VAULT-LIGHT FRAMING.
Tucker & Vinton, Inc., New York City, Builders.

The construction of the slab is shown by Fig. 2. A series of bull's-eyes or circular lenses 2⅝ ins. in diameter are placed in longitudinal and transverse rows 3⅝ ins. apart c. to c. These bull's-eyes are slightly tapering with circumferential ribs and a cup-like depression on the under side, and the spaces between them are filled with Portland cement and sand mortar inbedded around a ¼-in. square twisted steel bar. To construct the slab, a centering is built and templates are placed on it to center the lenses. The spaces are then partly filled with mortar, and the twisted bars are placed and covered with firmly packed mortar. The top of the mortar filling is struck off level with the tops of the lenses and the under surface is finished with a plaster or cement filling, as shown in Fig. 2, after the centering and templates have been removed.

The method of testing the slab illustrated was to place a steel disk 8½ ins. in diameter on it at the center of the middle panel and to load this disk with 27 × 27 × 12-in. rectangular building stones weighing about 914 lbs. each. These stones were placed one at a time by means of a derrick, and the appearance of the final load of 13 stones is clearly shown by Fig. 3. The weight of the final load was about 11,882 lbs., concentrated on a disk 8½ ins. in diameter or 0.394 sq. ft. in area. The resulting deflections as the stones were added one after another are shown by the following tabular statement:

Load, in lbs.	Deflection—Total.	Deflection—Reduced.	Load, in lbs.	Deflection—Total.	Deflection—Reduced.
914....	1/32-in.	1/32-in.	7,312..	5/8-in.	39/64-in.
1,828....	1/16-in.	3/64-in.	8,226..	3/4-in.	23/32-in.
2,742....	3/32-in.	6/64-in.	9,140..	7/8-in.	46/64-in.
3,656....	1/8-in.	5/32-in.	10,054..	17/16-in.	13/16-in.
4,570....	1/4-in.	12/64-in.	10,968..	13/16 ins.	11/16-in.
5,484....	5/16-in.	5/16-in.	11,882..	1⅞ ins.	1 41/64 ins.
6,398....	15/32-in.	25/64-in.			

At 5,484 lbs. the concrete began to crack and this cracking continued until the load reached 9,140 lbs. when the lenses began to crack. The breakage continued until at 11,882 lbs. crushing and in general breaking of the concrete and glass took place with the result shown by Fig. 4. After the removal of the load the slab returned to a permanent deflection of 1¼ ins. In the table given above the reduced deflections given are the figures obtained by subtracting in each case the deflection of the supporting beams from the total deflection given in the first column. While, as the result of the final load, the concrete and lenses were crushed as shown, the twisted rods were not broken and the slab continued to support its load.

Following the static load test an impact test was conducted. In this test a stone weighing 914 lbs. was dropped 17 ft. and struck on one corner directly over one of the 5-in. beams. The effect of this blow was to deflect the beam permanently about 4 ins.; to pierce a 9 × 12-in. hub through the slab and bend but not break the steel rods, and to break about 20 lenses. The same stone was then dropped from a height of 19 ft. 4 ins., striking on its end, at the middle of one end panel. The effect of the blow was to smash a large hole through the concrete and to bend the steel rods but not to penetrate through the slab. The purpose of the impact tests was to demonstrate the effect on the vault lights of heavy objects falling from the second story windows of buildings.

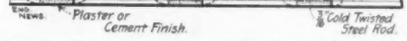


Fig. 2. Enlarged Section of Portion of Vault-Light Slab, Showing Construction.

For the information from which this description has been prepared we are indebted to Messrs. Tucker & Vinton, of New York city, the makers of the vault light tested.

FIG. 3. VIEW SHOWING VAULT-LIGHT SLAB, WITH CONCENTRATED LOAD OF 11,882 LBS. ON 8½-IN. DISK.

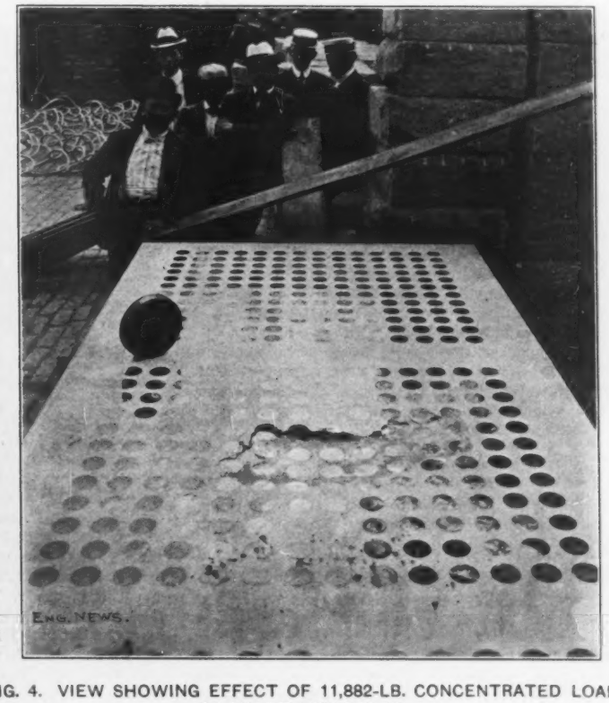


FIG. 4. VIEW SHOWING EFFECT OF 11,882-LB. CONCENTRATED LOAD ON VAULT-LIGHT SLAB.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The Electric Vehicle Co., whose peculiar financial methods were commented on in this journal two years ago, is having its affairs made public through a suit brought by a stockholder against the company's directors on the charge that they have paid dividends not out of earnings, but out of the company's capital. The stock of the company has been quoted as high as 130 for the preferred; but it is now down to 10 or below.

The report of the company's finances, published in "Poor's Manual" a year ago, appears to substantiate the charge. According to this, the company's operations from Jan. 1 to Aug. 31, 1901, showed the following results:

Earnings:		Expenses:	
Patent licenses	$155,000	Legal expenses	$9,257
Sale of vehicles	412,143	Taxes	8,703
Other sources	6,387	General expenses	17,000
		Contingent exp'n's.	4,722
Total	$573,530	Total	$40,282
Net earnings			$533,248
Paid dividends			324,800
Undivided profits			$208,448
Profit on investments			1,028,000
Total undivided profits			$1,236,448

The company's statement also showed treasury resources on Sept. 1, 1899, of $6,117,290, of which $1,575,185 was cash. Notwithstanding this fat treasury, in the suit above referred to it is alleged that the company was obliged to borrow $1,500,000 last April to avoid suspension of business and mortgage all it had as security. It is also alleged in the suit that the company has paid out in all over $700,000 in dividends, which were never earned.

About two years ago we called attention to the foolish and fraudulent speculation which was being carried on in the motor vehicle field, companies having been incorporated with a total capitalization of nearly $450,000,000 to engage in the business.

Most of these concerns never existed save on paper, and of the few which did undertake to do business only those have achieved a success which were organized on legitimate business principles.

In view of the claims and counter claims that have been made in relation to the invention of the septic tank, a valuable service has been rendered to the engineering profession by Mr. Leonard Metcalf, Assoc. M. Am. Soc. C. E., by his paper on "The Antecedents of the Septic Tank." The paper was published in the "Proceedings of the American Society of Civil Engineers" for May, 1901, and will be read before the society on Sept. 18. We think most engineers who read the paper will agree with Mr. Metcalf in his final conclusions that the following methods or details "are old in application in the field of sewage disposal, and hence that their use, 'per se,' cannot constitute an infringement of patent rights:" Sedimentation; liquefaction of solids by bacterial and other processes carried on in a tank; submerged inlets and outlets to and from sewage tanks; covering tanks; both the ventilation and absence of ventilation of tanks; removal of sludge without draining; overflow and aeration by means of a weir. The chief question at issue, if ever any of the recent patents on the septic tank and its accessories come to a test in the courts, will be whether patents on some combination of the foregoing are valid. The most essential elements in the design and operation of septic tanks, it appears from Mr. Metcalf's paper, have been in use for many years. The septic process is so simple, and in the cesspool and its modifications so universal, that it is not easy to see why any engineer who wishes to utilize anaerobic bacteria as a partial means of purifying sewage cannot easily enough do so without bringing his clients to the alternative of patent royalties or litigation. Some communities may submit to a more or less nominal claim for a royalty, rather than be bothered with lawsuits. Doubtless there will be attempts to find just such communities in order that they may be used as a lever to obtain more substantial payments elsewhere.

The 1,000-ton barge canal scheme to replace the present Erie Canal is to be actively pushed before the New York legislature this winter, by the commercial organizations of New York city and Buffalo. The remainder of the State, except on the direct line of the canal, is either lukewarm or actively opposed to the project. On the other hand, there is strong likelihood that the project for a 21-ft. ship canal, to be built by the National Government over practically the same route, will be taken up at the approaching session of Congress, and the success of that would mean, of course, the abandonment of the smaller enterprise. New York is not likely to pay $50,000,000 to $80,000,000 for one canal if the National Government will build a larger one across its territory free.

It is interesting to note in this connection, too, the opinion of Mr. Geo. Y. Wisner, of the U. S. Deep Waterway Commission. In a recent discussion before the American Society of Civil Engineers, Mr. Wisner declared that a decision in favor of the 12-ft. canal for 1,000-ton barges would cause work to be begun within a year on a 21-ft. ship canal from Georgian Bay to Montreal, via the French and Ottowa rivers. In other words, according to Mr. Wisner, the promoters of the Canadian Ship Canal are waiting "to see which way the cat will jump." If the decision is in favor of a 12-ft. canal, they will begin their work in the belief that their route can win in the competition. They dare not begin, however, until the projected United States ship canal is definitely disposed of, realizing that the inauguration of such a work would ruin their enterprise.

We called attention in our issue of Aug. 22 to the revolutionary proposition laid down in a paper on the flow of water to be presented to the American Society of Civil Engineers.. This proposition, briefly stated, is that sharp curves in a water main offer less resistance to the flow than easy curves. The authors of the paper are Prof. Gardner S. Williams, of Cornell University, and Messrs. Clarence W. Hubbell and Allen H. Fenkell, of the Detroit Water-Works, where the experiments which the paper describes were chiefly made.

The paper was presented at the meeting of the Society last week; but called forth little general discussion. The members who were unconvinced by the proofs presented in the paper—if such there were—doubtless thought that their criticisms had better be committed to writing; and numerous written discussions were filed which will be published later in the "Transactions."

It may be of interest to very briefly state the evidence which the authors presented in support of their proposition: A long line of water main was laid with a number of right angle turns, and these turns were made with curves of various radii. The friction or resistance to flow of these various curves was then compared; or rather, a length of 200 ft. of pipe was chosen in each case so as to include the curve at the center and enough tangent at each end to make exactly 200 ft., and the resistance of these various 200 ft. lengths of pipe was then compared.

When the comparison was made it was found that the 200-ft. lengths with the easy bends showed more friction than the 200-ft. lengths with the sharp bends. After repeating these measurements under a great variety of conditions, and with a painstaking attention to details designed to preclude the last possibility of error, the authors conclude that all the previous hydraulic experimenters have been wrong in stating that easy bends cause less friction in a pipe or conduit than sharp bends.

Naturally, such a radical departure from preconceived ideas needs to be tested at every point before acceptance. There is one point (not covered very clearly in the paper) which may possibly explain the anomalous results obtained. In the first place, it is admitted by the authors that the minimum friction in their experiments was shown by a bend with a radius of about 2½ diameters. This for a 16-in. pipe would mean a radius of 3 ft. 4 ins. If the reader will sketch a 90° bend with such a radius, he will see that such a turn is by no means a sharp one. It is what a plumber would call an "easy bend," and the authors admit that with any sharper turn than this the friction increases very rapidly. What they also claim and attempt to establish is that the friction of a 90° turn also increases as the radius increases from this point up to bends as large as 60 ft. radius on a 30-in. pipe. Their experiments appear to show that such an increase took place. The question is, what can have caused such an increase except the larger radius of the pipe?

It will be of interest here to note the explanation offered by Mr. Williams, for the phenomena observed. He points out that the length of a 90° curve increases, of course, as the radius increases; and he thinks that the long length of easy curve, offers on the whole more friction than the short length of moderately sharp curve. It is possible, however, it seems to us, that the real cause of greater friction in these longer curves may be the greater number of joints they contain as compared with the lengths having the sharper curves. While the pipe on tangents was laid in 12-ft. lengths, the curves had to be made up of much shorter sections. Details are wanting in the paper as to the relative number of joints in the several 200-ft. lengths of pipe tested; but it is obvious that the number of such joints must have increased with the increase in radii and length of the curves. Apparently the authors have considered the resistance of the hub-and-spigot joints in cast-iron pipe to be so small a part of the pipe friction that variations in the number of joints could be ignored. Perhaps this is so; but when one runs counter to long accepted scientific facts, no loop-hole for doubt should be left.

On the other hand, the practical lesson of their experiments is not altered whether the friction of the joints be much or little. The joints are an essential part of the pipe line, and since long radius curves require their use in larger numbers, the friction due to their use, be it more or less, is a necessary accompaniment of such

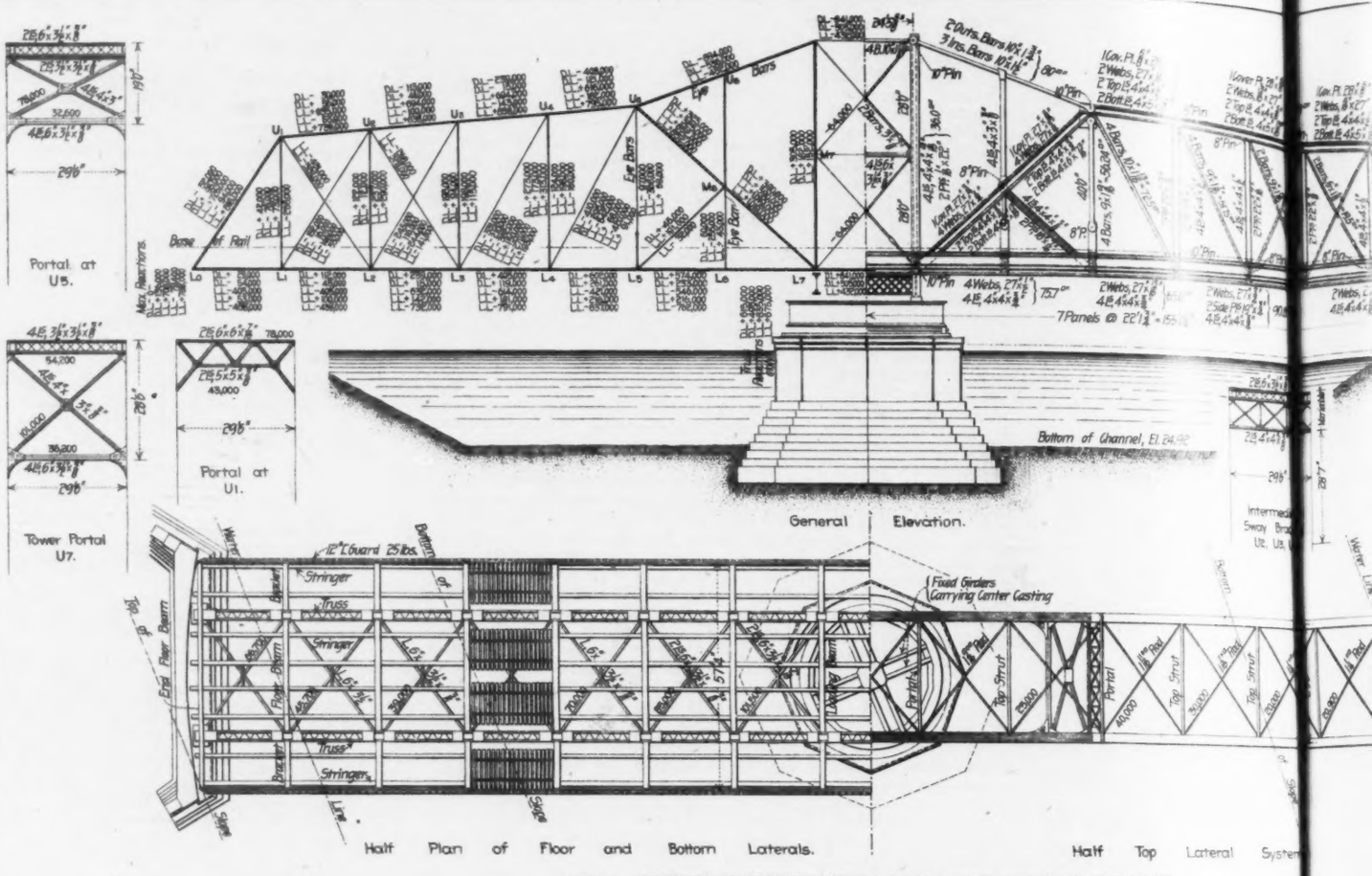


FIG. 4. GENERAL ELEVATION WITH STRAIN-SHEET, SECTIONS AND PLAN.

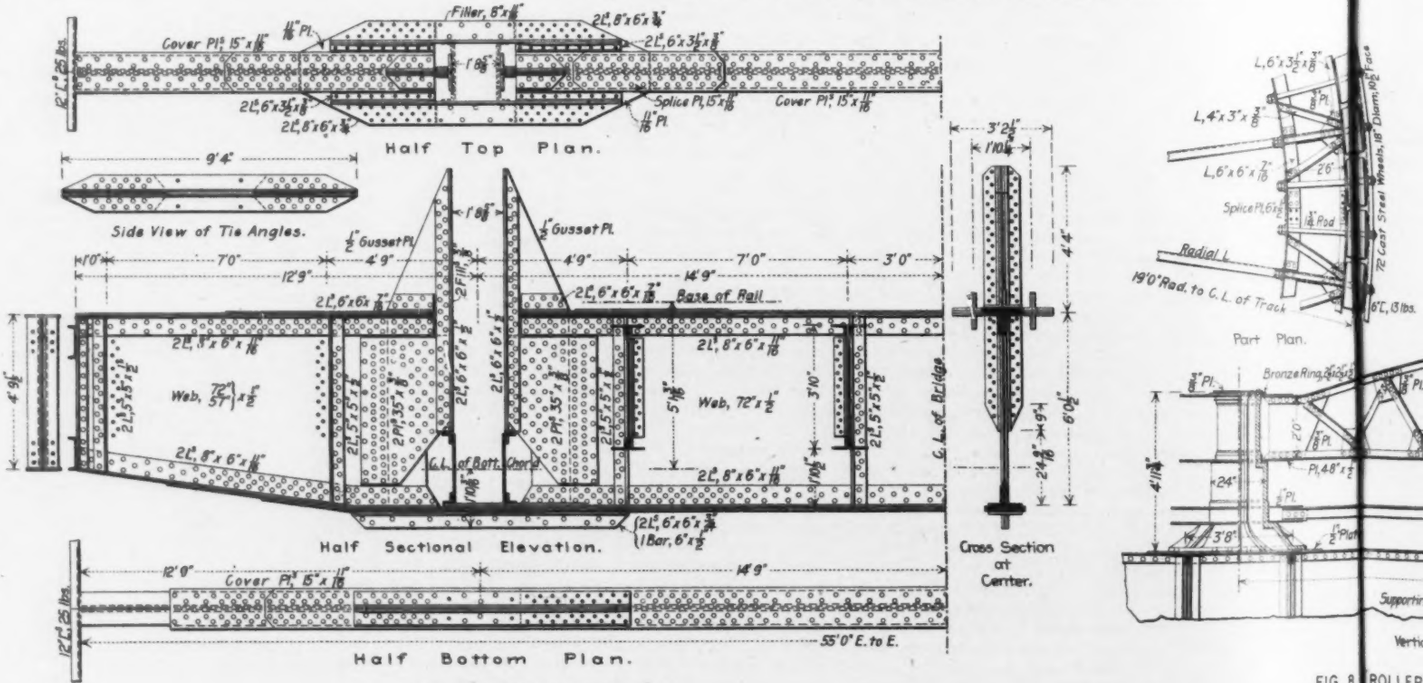


FIG. 6. FLOOR-BEAM DETAILS.

FIG. 8 ROLLER

FOUR-TRACK TWO-TRUSS SWING BRIDGE OVER THE CHICAGO D

Wm. Hughes, M. Am. Soc. C. E., Designing Engineer.

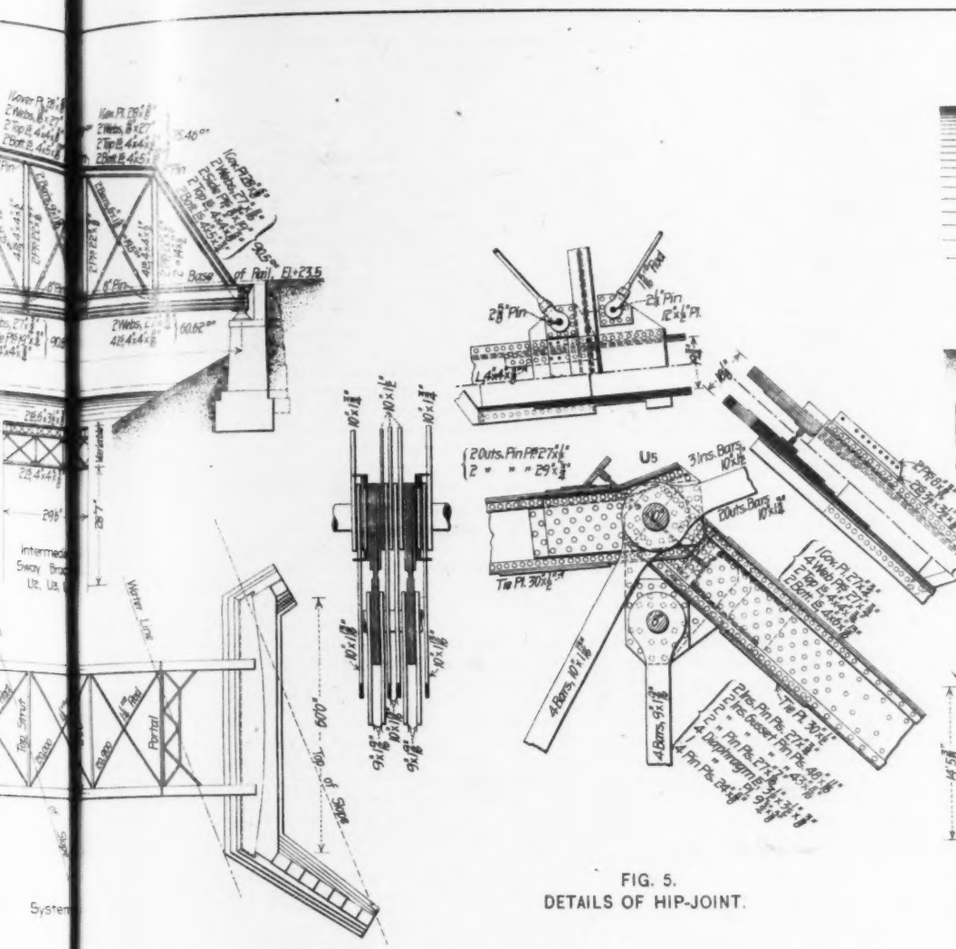


FIG. 5.
DETAILS OF HIP-JOINT.

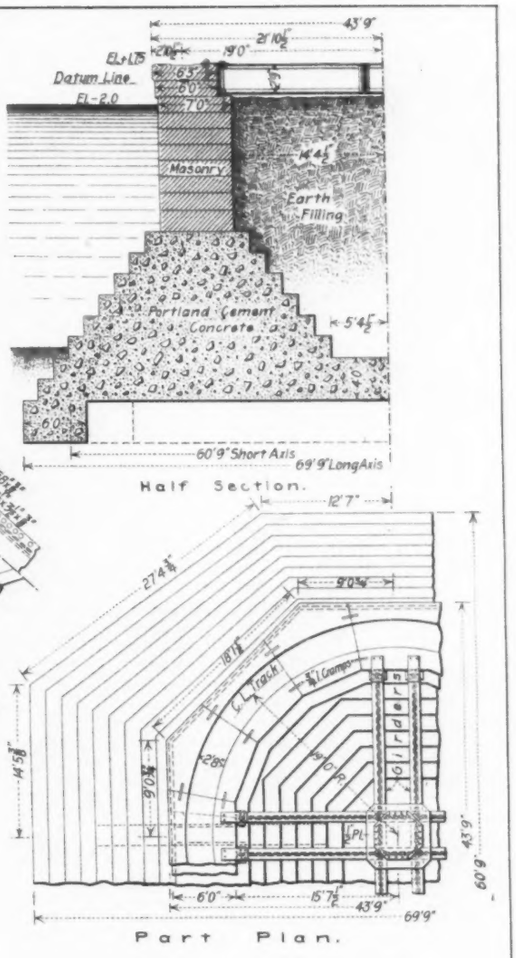


FIG. 3.
CENTER PIER DETAILS.

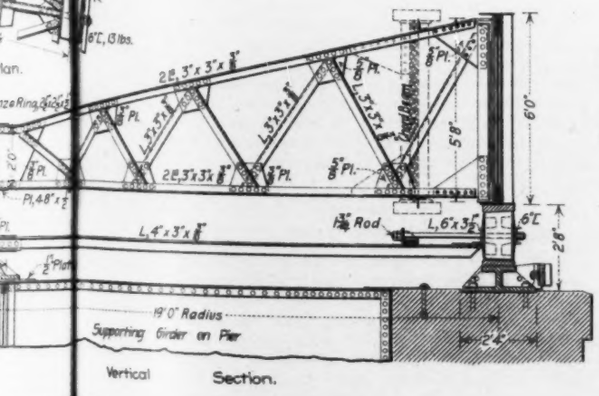


FIG. 8. ROLLER CONNECTIONS OF TURNTABLE.

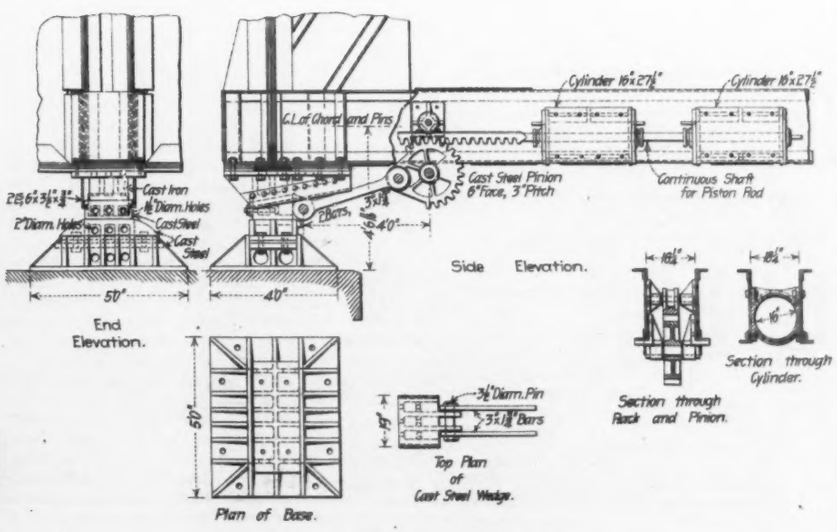


FIG. 9. END LIFT CONSTRUCTION.

CHICAGO DRAINAGE CANAL: CHICAGO & WESTERN INDIANA R. R.

E. H. Lee, Chief Engineer, C. & W. I. R. R.

CHAS. HART, LITH., 88 VESEY ST., N. Y.

curves. Since such curves on a pipe are always expensive and difficult of construction, it will be a relief to engineers to know that their use is of no benefit.

Probably it is a question in the minds of most engineers whether or not the gas engine can as yet be economically substituted for the steam engine in moderately large-sized power plants. That in the hands of a number of builders the large gas engine has reached a point where it can fairly rival the steam engine in reliability and good running qualities there can be no doubt, and, as engine-runners become better accustomed to the new motor, complaints on this score will rapidly decrease. In point of fuel economy, as is well known, a gas engine of moderate size is on a parity with the largest and most completely equipped triple-expansion steam engine. Either will give a HP.-hour for each 1 to 1¼ lbs. of coal fed into the gas generator or boiler furnace. The remaining items are cost of plant and availability. Now that there are at least two systems (the Mond process and the Loomis process, described elsewhere in this issue) by which power gas can be successfully made from bituminous coal, or in fact any kind of fuel, the gas engine and steam engine are everywhere equally available. The remaining question of first cost is really the vital one. We are informed that a complete gas-producer plant can be erected for 125 to 140% of the cost of a corresponding complete steam boiler plant. A difference of this magnitude might easily be offset by increased economy in operation. But when we consider the engines the difference is far greater. The gas engine weighs two or three times as much as a steam engine of equal power, and the cost is in nearly the same proportion. Moreover, we are told that it is difficult to secure large gas engines in the market at the present time. The question confronting us, then, is for the gas-engine manufacturer to solve. To the conservative engineer the gas engine is, as it always has been, a very interesting machine with great possibilities, but for general large power purposes its cost is still prohibitory.

A useful addition to existing indexes to technical literature is a new index to the "Transactions of the American Society of Civil Engineers," covering the entire series from Vol. I. (1867) to Vol. XLV., issued in June of the present year. Up to this time the transactions of this society have been covered by three separate indexes, one covering volumes 1 to 21; the second, volumes 22 to 27; and the third, volumes 28 to 34; volumes 34 to 45 had not been indexed at all. These old indexes, moreover, were ludicrously defective. Opening almost at random we find such reference words as "New," "Notes," "Observations," "Rapid Leveling," "Recent," "Reconstruction," etc. In the new index, careful search fails to show any such defects. The heads appear to be well chosen to guide the searcher after information on a particular subject.

Such indexes are a labor-saving tool of the greatest value to every engineer in making use of technical literature. Without their aid, in fact, the file of bound volumes of an engineering journal, or the proceedings of an engineering society, lose a great part of their value.

RACING STEAMBOATS AND EXPLODING BOILERS.

In casting about for a cause to which to ascribe the recent fatal steam boiler explosion on a Delaware River steamer, the newspaper press has had much to say about steamboat racing. The Philadelphia papers have filled columns with the testimony of people who saw, or thought they saw, the wrecked boat racing to beat a rival; and other columns have contained the theories of others as to why the steamer might, could, would or should have been racing or have not been racing. Sage editorials have been written, warning those in charge of steam vessels not thus to trifle with the public safety. The interest has spread far beyond Philadelphia, and one newspaper on the banks of the Hudson holds up the Trenton disaster as a terrible warning to the steam lines on that river. If they have raced, let them race no more; if they have not raced, let them take warning and abstain.

It appears to us time that a little knowledge was injected into this discussion. The good intentions of the newspaper editors who have sounded the warning against steamboat racing are undoubted; and their desire to combat evils which threaten the public safety is admirable. There are surely ills enough from which the public actually suffers on which these writers can train their guns and not expend their ammunition on shadows.

The belief that steamboat racing is dangerous is easily traced back to the "good old days" of steamboating on the Mississippi River. We have all heard the stories how the rival captains of racing boats, in their determination to win, would send a darky roustabout to roost on the safety-valve while the furnaces were fed with casks of rosin, turpentine, or whatever other rapid combustible the cargo afforded. Under such conditions, boilers not infrequently "let go." It would have transgressed the laws of physics, and the mathematical theory of probabilities if they had not.

A succession of these events—they can hardly be called accidents—educated the public to the belief that steamboat racing was dangerous; and that belief still survives. In fact, so tenacious of life is it, that many engineers, even, will doubtless be surprised if we assert that, so far as boiler explosions are concerned at least, there is nothing particularly dangerous about steamboat racing at the present day between such boats as ply on the ocean or on Eastern rivers and lakes. Let us see if we can explain the reasons for this assertion.

The Western river steamboat, whose skyward-mounting boilers have convinced the public of the dangers of steamboat racing, is a peculiar craft. Built to run "anywhere in a light dew," the saving of weight is a paramount feature in its construction, and its boilers are built of material as thin and light as the rules of the United States steamboat inspectors will permit. Its engines were not compounded in the old times, and it is seldom done now. The steam is exhausted to the atmosphere, no condensers being used. Further, in the old racing days, the boiler pressures, though high for those days, were low in comparison with the pressures in ordinary use in marine boilers to-day.

With boilers and engines of such a type there was not a little to be gained in the way of speed by propping the safety-valve down or perching a colored party on the lever, in the traditional way.

With the boilers and engines in use on Eastern waters, however, the case is entirely different. Take, for example, the "City of Trenton," on which the recent fatal explosion occurred. She carried a steam pressure of 150 lbs., and the safety-valve was set to blow off at 160 lbs. Her engines were triple-expansion and condensing. Now with such a steam plant, suppose the safety-valve were loaded with extra weight, so that the boiler pressure could be run up to 200 lbs. It is possible that the vessel's speed might be very slightly increased; but it is also possible that it might actually fall off, as a result of such a change. It must be borne in mind that the gain in power is not directly proportional to the increase in steam pressure. There is a little more available energy in a pound of steam at 200 lbs. pressure than at 150 lbs.; but the increase is not 25%, and nothing like it. Further, the gain in power falls off rapidly as the pressures run up. There was a large gain, for example, in raising the pressures from the old-time 25 or 30 lbs. up to 75 or 100 lbs. There was a much smaller gain in raising it to 150 lbs., and the gain will be still smaller in raising this to 200 lbs.

But the raise of steam pressure may not cause a gain in speed at all. The engines of a boat are designed to use steam at, say, 150 lbs. pressure, and will give, on the whole, better results there than they will if worked at a higher pressure. If a steamboat is to really race, or try to reach over a long course, the limit of speed of which her machinery is capable, the crucial point is the amount of steam the boilers can furnish. The engines will be set to cut-off in the high-pressure cylinder at just as late a point in the stroke as can be done without drawing steam away from the boiler so fast that the pressure will fall. Upon the energy of the fire-room force, then, the speed of the vessel will depend.

The firemen, however, have nothing but coal to burn, and as a rule nothing but the draft of the vessel's funnels to help them. They cannot, like the old-time wielders of the poker on the Mississippi River boats, throw oil or pitch or lard into the furnaces when a race is on, nor can they turn the steam into the chimneys to increase the draft, as was done on the non-condensing engines of the Mississippi boats. All they can do is to fire their coal with care and skill, and in such a manner that the fire will burn as rapidly as possible.

But this they do in ordinary daily service. In fact, on most steamboats the vessel is driven at practically her top speed all the time. The passenger steamships that cross the Atlantic, for example, race against time all the way from port to port; and while this racing is dangerous in a fog, on account of risk of collisions, there is not the least danger in it so far as the boilers are concerned.

Briefly summed up, the first reason why an engineer on an Eastern steamboat does not fasten down his throttle-valve to pass a rival vessel, is that there is little or nothing to be gained by such a procedure. This, however, is not the only reason; there are few engineers—very few we hope and believe at the present day—entrusted with the responsible charge of any passenger steam vessel, who are so densely ignorant or so criminally reckless with their own lives and those under their care as to tamper with the safety-valve on the boiler. Still further, to reach the possible one in a thousand or one in ten thousand who might venture on such a procedure, it is very generally customary to provide marine boilers with a locked and sealed safety-valve, which an engineer cannot load down be his will never so good—or bad.

The public and the newspapers are entirely right in wanting to know the cause of the fatal disaster on the "City of Trenton." That a nearly new boiler should explode in such a manner and with such fatal results points inevitably to something wrong somewhere; and it is to be hoped that the investigation to be made by the U. S. Inspectors may reach the bottom of the mystery.

It has been our effort in what we have written above, to endeavor to set the public right, and to stimulate the search for the real cause of the explosion, instead of an imaginary one. The "City of Trenton" may have been racing—or let us say, steaming at her highest speed—when the explosion occurred. Whether she was or not, in all probability, had nothing to do with the cause of the explosion, unless some one was so criminally ignorant and reckless as to tamper with the safety-valves. We have given several strong reasons above why any such tampering was in the last degree improbable.

LETTERS TO THE EDITOR.

Reasons for National Instead of State Control of Irrigation Works.

Sir: I would like the privilege of calling attention to certain statements made by Mr. Fred Bond, State Engineer of Wyoming, on pp. 91 and 92 of your issue of Aug. 8, 1901. Under section 2 of Mr. Bond's proposed national irrigation bill, which provides for a state administration, it is provided that:

> Any of the above named states or territories desiring to avail itself of the benefits of this act shall enact a law or laws accepting its conditions, and shall create a state engineer's office, with authority to make examinations and surveys, plans and estimates for reservoirs, etc.

In his comment on the bill he says:

> The work of the government is to continue without interference or interruption, the intent being to provide a law that would require the enactment of no other law preliminary to its going into effect, thus avoiding complications and the delays and oppositions that always attend them.
>
> * * * * * * *
>
> It was felt by the conference that only the complete and thorough information found in the state offices having the water appropriation in charge should or could be relied upon to determine when a reservoir is needed and where it should be located to attain the highest good. The correct, complete and reliable information already

fluence greater even than that caused by the viscosity of the water. In any experiments, therefore, in order that their results may be applied to practical use, we should know the condition of the interior surface of the pipe experimented upon, and be able to compare it with some fixed standard. It is a common practice to use the term "clean" or "smooth" to indicate such standard of comparison, the standard itself being, however, very vague, though a well cast pipe thoroughly coated just from the foundry might reasonably be supposed to represent it.

But one important consideration is often lost sight of in this classification. Practically we are not concerned with a cast-iron pipe, but a line of cast-iron pipes. Each pipe may be as clean and smooth as it is possible to turn it out, but there is a joint at every 12 ft., more or less, and innumerable deflections, both horizontal and vertical, from a straight line. If all these changes of direction were accomplished by means of special pipe cast to the proper radius, their effect would be comparatively insignificant, but except in very superior work, or on very pronounced bends these deflections are overcome by slewing the pipe at the socket for slight variations, and by using cut pipe and sleeves for sharper ones. These causes occasion very serious solutions of continuity in the integrity of the pipe walls, leaving the surface very far from smooth, although it may be perfectly clean. It is this consideration more than any other that gives the deathblow to any possible utility derivable from highly refined pipe formulas.

But there are other difficulties which beset the path of the investigator who desires to deduce a general formula from his experimental results, as an illustration will show.

Let us suppose that an experimentalist, whom we will designate as A, has carefully measured the discharge of a line of "clean" 12-in. pipe having an hydraulic grade of 1 per 1,000, and from it has deduced the velocity of flow, V. In the formula,

$$V = C\ D^x\ S^y,$$

he now knows V, D and S, and obviously can vary C, x and y indefinitely, and quite at will, provided that each combination gives the correct value of V.

A second observer, B, has made precisely the same experiment with another "clean" pipe line, same diameter and same slope. He should, of course, get the same value of V. Equally, of course, and even more so, he does not. He too, prepares a formula which gives the correct value of his observed velocity, using the same form but probably a different combination of variables from A. Each observer has a formula which gives with mathematical correctness the velocity of his own pipe line, but would give a wrong result if applied to the other. If now an hydraulic engineer, C, wishes to know how many cubic feet per second his prosoped 12-in. pipe line will deliver under a fall of 0.001, he can take his choice of either A's or B's formula, with the almost mathematical certainty that his practical result will differ from both.

But, again: A raises the upper end of his line, so that he now gets a slope of say 5 per 1,000, and ascertains, experimentally, the value of V. He finds that his formula no longer holds good. It evidently is not general, and he must modify it, so that it will embrace both observed results. He can do this by changing all, or any two of the variables C, x, y. This will give him a formula correct for his particular pipe line, and for values of S of 0.001 and 0.005, but not necessarily for intermediate values.

Meanwhile, B has been doing the same with his line, and has also found his formula to be faulty. He modifies it accordingly, but probably differently from A. Here now are two formulas giving not only different vales of V, which is natural, but having also different coefficients and exponents, which is irrational.

Should our two experimenters continue their investigations on other pipe lines, not only of different slopes, but also of different diameters, and progressively change their variables, so as to include each new result, they would continually increase the number of cases for which their formulas held good for their separate pipe lines, and would continually approach each other and the truth, until finally the only significant difference would be in the coefficient C, which would be the characteristic of their respective lines. I am assuming, of course, that there could be a general formula of the given form.

If not only A and B, but the rest of the alphabet also should carry on the same series of experiments not only on so-called clean pipes, but on all the varieties met with in practice, an average value of C would be found, or rather, and still better, extreme limits would be found between which C varies with the character of the pipe walls.

Experimental investigation has not yet gone so far as this. Our formulas are based upon a few experiments made on comparatively small diameters, and have been generalized and extended beyond the limits within which observation shows them to be true. Taking those of the form given by Mr. Bailey, it is clear that if the values of x and y are assumed arbitrarily, although they can be made, with the assistance of C, to fit a few known values of V, yet if not following a correct law they must give increasingly erroneous results the more the diameters and slopes differ from those af the experiments.

The question then arises, are there not natural laws which govern the values which can rationally be attributed to x and y? The only influence producing flow in a pipe line is the force of gravity, and the velocity of that flow depends upon the steepness of slope of the hydraulic grade. This velocity must be governed therefore by the law of gravitation, one form of which is $V = \sqrt{2\ g\ h}$, that is, velocity is proportional to the square roof of the height of fall, so that if we quadruple the height, we double the velocity. Are we justified, in view of this fact, in giving any other value to y than ½? It will be observed that several of the formulas in Mr. Bailey's table give greater values than this, one being as much as $^4/_7$. It seems unreasonable to suppose that in rough practice gravity should impart a greater velocity than it does in a laboratory experiment. If there is any difference one would expect it to be the other way.

Again, it seems to be well established that resistance to flow varies as the square of the velocity, or nearly so. On the other hand, resistance varies as the area of the surfaces in contact, and this varies, in a pipe, as the diameter. Should not the velocity vary, therefore, as the square root of the diameter? In other words, should not x also equal ½? It certainly appears to me that in a rational formula, based on known natural laws, the velocity of flow should vary as the square roots of D and S.

If this view is correct, the rational formula of the form given by Mr. Bailey would be

$$V = C \sqrt{D\ S}.$$

This is the formula of Chézy, Darcy and others.

It must always be borne in mind by the practical hydraulic engineer, that the delivery of water through a "clean" pipe corresponds to the "breaking stress" in a steel girder. No structural engineer would think of using the latter in practice, without allowing a large factor of safety. Why should not the hydraulic engineer use the same prudence in his calculations?

Yours truly, E. Sherman Gould.

Yonkers N. Y., Aug. 20, 1901.

(Proofs of the above letters were submitted to Mr. Bailey, and we append his reply.—Ed.)

Sir: I have read with much interest the communications from Mr. John C. Trautwine, Jr., and Mr. E. Sherman Gould.

I agree with Mr. Trautwine that Kutter's formula in many cases applies very satisfactorily to flow in pipes. The numerous diagrams based on this formula which have been prepared by various persons, together with the translation of Ganguillet and Kutter's work by Messrs. Hering and Trautwine, have doubtless aided in establishing the popularity of this widely known and useful formula.

Mr. Gould states near the beginning of his letter that "it may be remarked that Mr. Bailey's list does not exhaust the number of formulas of this form, and omits two of the best known ones—Chezy and Darcy's."

The coefficient C in the Chezy and Darcy formulas is a variable one, and for that reason I did not include it in the table, which, as I stated, included only those formulas in which C was a constant.

Mr. Gould further says:

The only influence producing flow in a pipe line is the force of gravity, and the velocity of that flow depends upon the steepness of slope of the hydraulic grade. This velocity must be governed, therefore, by the law of gravitation, one form of which is $V = \sqrt{2\ g\ h}$; that is, velocity is proportional to the square root of the height of fall, so that if we quadruple the height we double the velocity. Are we justified, in view of this fact, in giving any other value to Y than ½?

It would appear that if the resistances to the force producing flow in the pipe were constant under all slopes that Y should be given the above value, but I believe it is generally considered that the resistances are not constant on all slopes. Several able experimenters have reported that the value of Y is generally greater than ½.

Mr. Gould also says:

Again, it seems to be well established that resistance of flow varies as the square of the velocity, or nearly so. On the other hand, resistance varies as the area of the surfaces in contact, and this varies in a pipe as the diameter. Should not the velocity vary, therefore, as the square root of the diameter. In other words, should not X also equal ½?

The resistance to the flow of water in a pipe decreases in amount from the interior surface to the center of the pipe; but the rate of decrease is uncertain, and it should seem until this rate and the laws governing it are known that it is impracticable to derive by theory an absolutely correct value for X. Yours truly,

Frank S. Bailey.

Room 140, State House, Boston, Mass., Aug. 28, 1901.

Concerning Mr. Edward Wilmann.—Correction.

Sir: My attention has been called to an item in your issue of this week, and which appears in the column of "Personals," referring to Mr. Edward Wilmann. As the representative of Mr. Wilmann, and on his behalf, I wish to call your attention to the gross injustice which this item does to him and to ask that you publish such correction as even a cursory investigation of the facts will show to be in order. And that there may be no misunderstanding as to the facts, I herewith quote the official record of the charges against Mr. Wilmann filed with the Civil Service Commission by the City Engineer, as follows, viz.:

Chicago, August 21, 1901.

Department of Public Works, Chicago. Bureau of Engineering. John Ericson, City Engineer.

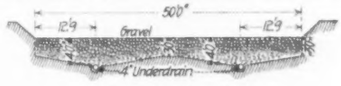
Mr. Edward Wilmann, 1356 No. Sawyer Avenue, City:

Dear Sir: You are hereby discharged from the city's service as bridge engineer for incompetency, neglect of duty and conduct unbecoming an official of the city. Should you desire a hearing on these charges, you will notify the Civil Service Commission in writing to that effect within 15 days from this date. Yours truly,

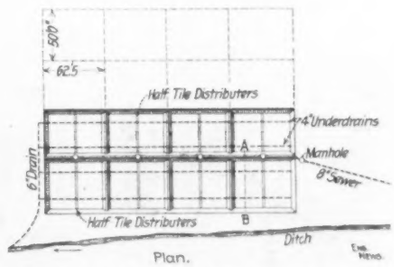
(Signed) John Ericson, City Engineer.

You may verify the above on inquiry at the office of the Civil Service Commission and will readily observe that the item above mentioned from your publication is very far from being a correct statement of the facts.

I am willing to believe that this very serious error, which involves great injustice to Mr. Wilmann, is entirely



Cross Section A-B.



Plan.

Fig. 1. Plan and Section of Sewage Filter Beds for Montgomery Co. Infirmary, Near Dayton, O. Robt. E. Kline, County Engineer.

the result of mistake, and that you would be the first to correct the same when called to your notice.

It is only justice to Mr. Wilmann to say that he has demanded a sweeping investigation of the above charges and also of his entire administration of the Bridge Division of the Engineering Bureau of the Department of Public Works of the city, and that such investigation is now set for Sept. 12.

I therefore ask that you publish this communication, or make a correction of the error in as conspicuous a manner and place in your publication as was given the error.

Very truly, Western Starr.

40-107 Dearborn St., Chicago, Sept. 7, 1901.

SEWAGE DISPOSAL BY INTERMITTENT FILTRATION AT THE MONTGOMERY CO. INFIRMARY, NEAR DAYTON, O.

By Benj. H. Flynn, Jun. Am. Soc. C. E.*

This institution occupies a 160-acre farm, located a few miles west of Dayton, on the high rolling land back from the valley of the Great Miami River. During the past year it sheltered, on an

Fig. 2. View of Sewage Filter Beds, with Infirmary in Distance.

average, 382 inmates, who were cared for by 32 officers and attendants, making a total population of 414. The occupants are housed in three separate buildings, each fitted throughout with water under pressure and with water closets. The discharge from the closets, together with the waste from the kitchen and laundry, is collected in 6-in. tile sewers which lead to an 8-in. outfall sewer.

Owing to the absence of a stream of a size sufficient to care for the sewage by dilution, it was

*Engineer Ohio State Board of Health, Columbus, O.

acquired by many of the arid states, coupled with their facilities for obtaining data within their immediate boundaries, make them pre-eminently the proper authorities for determining these matters.

The States of Washington, Oregon, California and Nevada and the Territories of Arizona and New Mexico have no state engineering department, and, with the exception of California, never had. The State Engineering Department of California was abolished about 17 years ago. As the state of Texas has no national public land, it would naturally be debarred from Mr. Bond's programme.

It would seem that this portion of arid America is of sufficient magnitude to merit some consideration. In all of these districts, as well as in other portions of the arid West, the hydrographic branch of the Geological Survey, organized under the civil service and employing many local engineers, is and has been for a term of five to ten years gaging streams, surveying reservoir sites and studying the general problems relative to irrigation. In California, where I am particularly acquainted with this work, daily records are being kept on 20 streams, and some 50 reservoir sites have been surveyed and reported upon. It scarcely strikes me as fair, in view of these above mentioned facts, to leave unchallenged the glittering generalities of the quoted paragraphs.

As a matter of general interest and information, I may be permitted to again quote Mr. Bond:

> The acreage to be acquired by any one person is the same as that which he may obtain under the land laws now in force. * * * It is safe to say that a law restricting the area to be owned by each settler to a tract of 40 acres would not build a single home in the Rocky Mountain region.

It is the belief of many that irrigation necessitates intensive cultivation and that intensive cultivation will permit of denser population. In a certain portion of the fruit-growing districts of California there is an inhabitant supported to each 1⅛ acres of irrigated land.

The following table is taken from the eleventh census of the United States Report of Agriculture by Irrigation, p. 1. The census report for 1900 on this subject is not yet available:

Number of Irrigators, Area Irrigated, Average Size of Irrigated Farms and Average Value of Products Per Acre in Each State and Territory in 1889:

States and Territories.	No. of irrigators.	Area irrigated, in acres.	Average size of irrigated farms, in acres.	Average value of products per acre.
Total	54,136	3,631,381	67	$14.89
Arizona	1,075	65,821	61	13.92
California	13,732	1,004,233	73	19.00
Colorado	9,659	890,735	92	13.12
Idaho	4,323	217,005	50	12.93
Montana	3,706	350,582	95	12.96
Nevada	1,167	224,403	192	12.92
New Mexico	3,085	91,745	30	12.80
Oregon	3,150	177,944	56	13.90
Utah	9,724	263,473	27	18.03
Washington	1,046	48,799	47	17.09
Wyoming	1,917	229,676	120	8.25
Subhumid region.	1,552	66,965	43	——

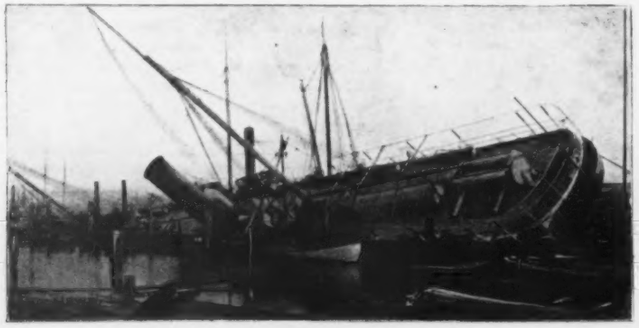
Another factor which would have bearing upon the proposed bill for state construction is the character of the greater portion of our large Western rivers. For instance, the Truckee River rises on the eastern slope of the Sierra Nevada. There are six or eight excellent reservoir sites in the mountains of California in the drainage basin on this river in which water could be stored at a commercial profit. One of the greatest and best reservoir sites on the Pacific coast is Lake Tahoe, which is divided by the California-Nevada line. Practically all the irrigable lands that could be reclaimed by these stored waters are in the State of Nevada. Under a programme of exclusive state construction it would be difficult to conceive how this situation could be satisfactorily adjusted. Under a broad national policy it would be different. What is true of the Truckee River would be true of the Colorado, the Rio Grande, the Arkansas and many other Western streams.

J. B. Lippincott.

Byrne Building, Los Angeles, Cal., Aug. 19, 1901.

Accident to a Vessel on a Marine Railway.

Sir: The accompanying photographs illustrate a somewhat peculiar accident which occurred to the steamship "Hudson" recently in Baltimore harbor. The "Hudson" is one of the fleet of the Merchants' & Miners' Transportation Co., and has been in service between Baltimore and Providence. Damaging one of the blades of her propeller, she was taken to the shipyard of the Skinner Shipbuilding Co. to be hauled out on its marine railway. This railway has an inclined track and is operated by a chain cable wound on a drum, being similar to the marine railways in general use along the Atlantic coast. The vessel was backed into a slip into which the railway extends, the cable was made fast, and she was pulled up the incline until the propeller blades were free of the water. Wooden props were placed under each of the rear quarters. The tide at Baltimore rises about 18 ins., and the vessel was pulled out at the flood. When ebb tide was reached the ship careened and fell against the side of the slip. Her railing and several deck timbers were crushed in and a number of plates in the hull were bent. The hatchways on the forward deck had been left open, and in careening these were forced under the surface of the water, with the result that about two-thirds of her hull was filled. The bow was forced into the mud at the bottom of the harbor to a depth of about 3 ft.



ACCIDENT TO THE STEAMER "HUDSON" ON A MARINE RAILWAY IN BALTIMORE HARBOR.

Efforts were made to right the vessel by carrying cables from the starboard side to the shore and attaching them to towboats, but the weight of the water and the fact that the bow was imbedded in the mud defeated this plan. A wrecking steamer was then sent for, and steps were taken to pump the water from the hold after divers had closed the portholes and other openings. After removing the water, cables were fastened to the masts and extended to the wrecking steamer and three of the largest tugboats in the harbor. By their combined efforts the "Hudson" was finally pulled over at high tide to an upright position and freed forward as well. The damage was principally caused by water in the cabins and in the engine room, and was estimated at about $5,000. The cause of the accident is supposed to have been the giving way of the props on one side of the vessel, although the shipyard owners claim that the props were ample to sustain the weight. The opinion of experts who investigated the accident is that the difference in depth of water at high and low tide affected the displacement of the ship to such an extent that more weight was thrown upon the props at low tide than they could withstand. M. D. A.

Baltimore, Md., Aug. 27, 1901.

Comparison of Formulas for Flow of Water in Clean Cast-Iron Pipes.

Sir: Noting the article with title as above, by Mr. Frank S. Bailey, in your issue of Aug. 15, I have very hastily computed the discharge in the several cases embraced within Mr. Bailey's table, with values of C, by Kutter's formula, taken mentally by interpolation from the tables in Trautwine's "Civil Engineer's Pocket Book," with n = 0.011.

It will be noticed that the Kutter formula gives, in most of the cases, lower velocities than those derived by means of the coefficients of Mr. Hamilton Smith, Jr., which Mr. Bailey assumes as "the proper ones to use as standards of comparison," especially with the steeper slopes; and the discrepancy is greatest with the small (2-in. and 6-in.) pipes. As is well known, the Kutter formula was derived from the results of experiments upon the flow of water in open channels, and was intended for application only to such flow; but it has been found to apply very satisfactorily also to flow in pipes.

Yours truly, John C. Trautwine, Jr.

257 S. 4th St., Philadelphia, Aug. 16, 1901.

Formulas for Flow of Water in Clean Cast-Iron Pipes.

Sir: The table of formulas for flow of water in clean cast-iron pipes, given by Mr. Frank S. Bailey, in the Aug. 15th number of Engineering News, affords food for reflection to the hydraulic engineer.

Mr. Bailey has confined himself to formulas of the form

$$V = C D^x S^y,$$

in which

V = velocity in feet per second;
D = diameter in feet;
S = sine of slope, or hydraulic grade;
C = a numerical coefficient,

and x and y exponents of D and S, respectively.

It may be remarked that Mr. Bailey's list does not exhaust the number of formulas of this form, and omits two of the best known ones—Chézy and Darcy's.

The results given by these formulas when worked out for various diameters and slopes, as shown by the table, arrest attention alike in their agreements and differences. The nearest agreements are in the low velocities, which is a suggestive fact.

I do not pretend to know the history of all the various formulas at present in the possession of the profession, but take it for granted that they are all based on experiments. Experiments to determine the velocity of flow through pipes are beset with many difficulties. In open channels, current meters and floats can be used with very satisfactory results, but this is evidently impossible with pipes, and the only trustworthy method for finding the mean velocity is to measure the discharge and divide it by the area of the pipe. While this may frequently be done with very little trouble in the case of small pipes, the difficulties rapidly augment with the diameters, for obvious reasons. Hence, nearly, if not quite, all of our formulas have been established by observations made on small pipes, and their verification by actual measurement when applied to large diameters is seldom possible. This is unfortunate, because it is precisely for large diameters and heavy deliveries that it is most important to know what can be expected from a given pipe line. Empirical formulas may be safely trusted for values differing but slightly from those for which they have been found to be true, but as the variation increases the chance of error increases also.

One very serious difficulty attends all such experiments. It is a well-known fact that the nature of the interior surface of a pipe has a very great influence upon the velocity of flow through it. It is hard for any one not familiar with the subject to realize the extent to which this is true. Even those who readily admit the influence which a foul bottom has upon the speed of a vessel going through the water, may be unprepared to realize that the same influence obtains when the water goes through the vessel. In the early days of the science of hydraulics water was assumed to be practically a perfect fluid, so that in passing over the bottom and along the sides of a channel of rough and irregular surface, it would simply level up the irregularities and thus establish an even surface over which to flow. And, indeed, it is probable that this would be to a great extent the fact, were it not for the eddies and counter currents set up by these irregularities which no doubt exert a retarding in-

Computed Velocities, in Feet per Second, of Flow of Water in Clean Cast-Iron Pipes, by Kutter's Formula; n = 0.011

Diameter, D	2 ins. = ⅙ ft.			6 ins. = ½ ft.			12 ins. = 1 ft.			36 ins. = 3 ft.			60 ins. = 5 ft.		
Mean radius $R = \frac{D}{4}$	0.04166 ft.			0.125 ft.			0.25 ft.			0.75 ft.			1.25 ft.		
Slope	0.004	0.05	0.20	0.001	0.01	0.10	0.0005	0.005	0.025	0.0001	0.001	0.01	0.00005	0.0005	0.005
$V = C\sqrt{RS}$	0.91	3.20	6.39	0.94	3.01	9.51	1.14	3.68	8.30	1.07	3.62	11.53	1.04	3.57	11.47
$= \frac{C}{2} D^{\frac{1}{2}} S^{\frac{1}{2}}$.															
C by Kutter's formula*	70	70	70	84	85	85	102	104	105	124	132	133	132	143	145

*Approximate.

efficiency and practical value of the various tests for hydraulic cements and concludes with specifications for Portland cement, natural cement and puzzolan cement. These parts of the report we print as follows:

GENERAL CONSIDERATIONS.

The constructing engineer is confronted by no problem more difficult than to decide whether a certain cement, when placed in a work, will behave in a predetermined way. This is especially true of Portlands. Other cements are much more reliable under conditions of exposure for which they are suited.

The difficulties arise from the fact that tests for acceptance or rejection must be made on a product not in its final stage. A cement, when incorporated in masonry, undergoes for months chemical changes in the process of setting, so that the material subjected to strains in the work is not the material tested, but a derivative of it. The object of tests is to establish two probabilities: First, that the product of the given cement will develop the desired strength and hardness soon enough to enable it to bear the stresses designed for it; second, that it will never thereafter fall below that strength and hardness. Up to the present time it appears that the relation between the chemical and physical properties of raw cement and of its partially indurated derivatives, determined by tests, and the physical properties of the same cement or its derivatives, after complete hydration and induration in the work, can be stated only within rather wide limits.

The most useful tests of cements are those, first, which connect themselves definitely with some serious defect to which cements are subject, or with some merit which they should possess; second, which can be made with the least apparatus and manipulation, and which give their indications in the shortest time; and, third, which are freest from personal equation and from influences of local surroundings. These criteria, applied to the customary tests of cements, give indications as to their relative value and the best methods of making them.

TEST OF GRINDING.

This test derives importance from the fact, apparently well established, that, other things being equal, the finer the cement the greater will be its sand-carrying capacity; that is, it will show greater strength with the same charge of sand, or equal strength with a greater charge. According to the best information the board can obtain, the cementitious value of this material is believed to reside principally, if not wholly, in the very fine part. It follows that a grinding test should be directed to determining the proportion which is very fine rather than the residue above a certain size. The board does not propose any change in the accepted grinding test of Portland cement, but favors for natural cement the use of the same size screen as for Portland, No. 100, with the requirement that 80% shall pass through it. The screen should be frequently examined, magnified, if practicable, to see that no wires are displaced leaving apertures larger than the normal.

TEST FOR SPECIFIC GRAVITY.

This test is made with simple appliances, and its result is immediately known. It appears to connect itself quite definitely with the degree of calcination which the cement has received. The higher the burning, short of vitrification, the better the cement and the higher the specific gravity.

This test has another value, in that the adulterations of Portland cement most likely to be practiced and most to be feared are made with materials which reduce the specific gravity. The test is therefore of value in determining a properly burned, nonadulterated Portland. If underburned, the specific gravity may fall below 3; it may reach 3.5 if the cement has been overburned. No other hydraulic cement is so heavy in proportion to volume, natural cement having a specific gravity of about 2.5 to 2.8 and Puzzolan (slag) of about 2.7 to 2.8. Properly burned Portland, adulterated with slag, will fall below 3.1.

TEST OF ACTIVITY.

This test, made by gaging the cement with water and observing the times of initial and permanent set, is partly direct and partly indirect. It is direct in so far as its limits relate to the time necessary to get the cement in place after mixing, which must not be greater than the time of initial set, and to the time within which the cement product must take its load, which must not be less than the time of permanent set. It is indirect in so far as its limits relate to the probable final strength, elasticity, and hardness of the cement mixtures. In the latter respect it appears to be reasonably well established that cements exhibiting great activity give, after long periods, results inferior to those with action less rapid.

The test for activity is easily made with simple appliances, and its results are known in a few hours at most. Variable results in the test are caused by different local conditions of moisture and temperature and by the different judgments of observers as to whether the needles penetrate or not. Generally speaking, both periods of set are lengthened by increase of moisture and shortened by increase of temperature. Some manufacturers claim that their cements show their best results when gaged with particular percentages of water. It is not considered good policy to encourage these peculiarities at the expense of the uniformity of tests which is so greatly desired. It is better to adopt a definite proportion of water for gaging and require all cements of the same class to stand or fall on their showing when so gaged. Such a percentage, adopted and known, will probably be used by manufacturers in testing goods sold to the Engineer Department, and a greater harmony between mill and field tests of the same cement will result.

In gaging Portland cement in damp weather the samples should be thoroughly dried before adding water. This precaution is not deemed necessary with natural cement. Sufficient uniformity of temperature will result if the testing room be comfortably warmed in winter and the specimens be kept out of the sun in a cool room in summer, and under a damp cloth until set.

TEST FOR CONSTANCY OF VOLUME.

This test results from observations made on the pats or cakes used in the setting test. It derives its value from its connection with the quantity of expansives in the cement.

The test is easy to make, and its results are relatively free from personal error, though there is room for a difference of judgment as to the appearance of the cakes. As they may be preserved and the decision reviewed at any time on the original data, such differences are immaterial.

TESTS OF STRENGTH.

These may be subdivided into compressive and tensile tests, the latter including the transverse test made by breaking a beam of the cement. The compressive test need not be further considered, as it is less easily made than the tensile test and gives no surer indications. The ratio of compressive to tensile strength of the same class of cements is quite uniform. Of the tensile tests the direct pull is preferable to the flexure test.

The tensile test is theoretically a perfect index of the quality of the cement at the periods of test, and a comparison at different periods gives the best obtainable indication of what its subsequent conduct will be. In the opinion of the board the two periods must generally adopted, seven and 28 days after mixing, are, on the whole the best. The one-day test, though of some value in a discriminating sense, should not be placed in the same category as the other periods named.

The apparatus for tensile tests is somewhat elaborate and delicate, but is of standard manufacture and readily obtainable at relatively small cost.

In respect of uncertainties due to the personal equation of the tester and to the influence of local conditions this test presents greater difficulties than any of the others considered. The most scrupulous care must be observed in the manipulations, and the tester should possess natural aptitude for such work. The object is to determine the greatest stress per square inch which the cement can be made to stand under given conditions without rupture. If the conditions have been carefully observed and several discrepant results are obtained, the highest may be right, but the others are certainly wrong. No averaging should be done.

The remarks made above under the activity test as to the relation between early hydraulic intensity and the final excellence of a cement product are equally applicable to the indications from tensile tests. A cement which tests moderately high at seven days and shows a substantial increase to 28 days is more likely to reach the maximum strength slowly and retain it indefinitely with a low modulus of elasticity than a cement which tests abnormally high at seven days, with little or no increase at 28 days.

ACCELERATED TESTS.

The rules recommended by the committee of the American Society of Civil Engineers in 1885 have been substantially accepted here and abroad as to tests of setting qualities and soundness; more rapid tests for soundness are, however, proposed and practiced, though no accelerated test has been generally accepted.

Accelerated tests proposed for the speedy detection of the presence of expansives in cement usually consist in the application, after gaging, of dry heat or of immersion in warm or boiling water or steam. The immersion tests are most in vogue. They vary from immersing freshly gaged pats on glass plates in water at 115° F. for 24 hours, or at higher temperatures for various periods, to steaming or boiling cakes or cylinders of the material to be tested at 212° F. for varying times.

In France and Germany the swelling or expansion of boiled cylinders is measured directly by calibration. Usually change of volume not accompanied by visible evidences of it—i. e., distortion or disruption—is not observed in American tests prescribed in specifications for the reception of cements. Of all these tests the boiling test is the simplest, requires only apparatus everywhere available, and is recommended by the board. It has been the experience that this test detects material that is unsound by reason of the presence of active expansives; but in some cases it rejects material that would give satisfactory results in actual work and will reject material that would stand this test after air slaking.

The great value of the test lies in its short-time indications and in at once directing attention to weak points in the cement to be further observed or guarded against. Of two or more cements offered for use or on hand, the cements that stand the boiling tests are to be

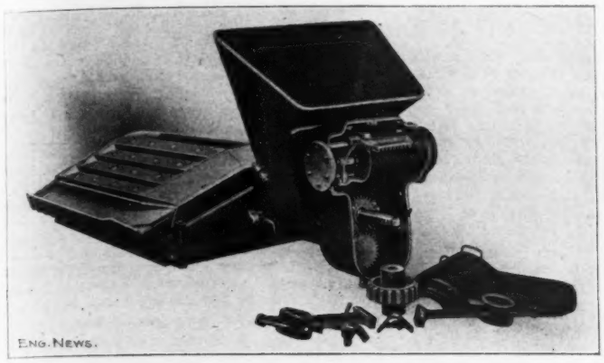


FIG. 3. THE IMPROVED UNDERFEED STOKER AS APPLIED TO AN ORDINARY BOILER FURNACE.

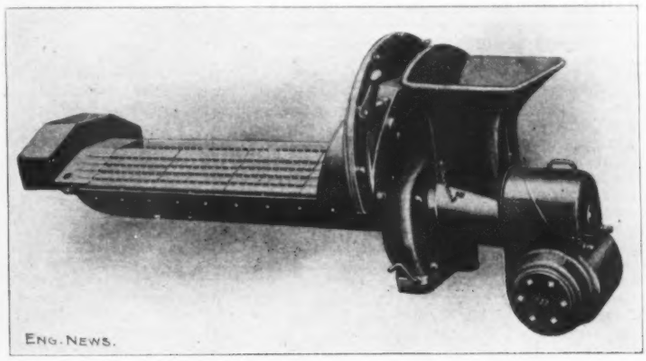


FIG. 5. PERSPECTIVE VIEW OF THE UNDERFEED STOKER AND ATTACHMENTS FOR MARINE BOILER FURNACE.

Fig. 4. Section Showing the Application of an Underfeed Stoker to a Marine Boiler.

necessary to put in purification works of some kind. In 1898 plans for intermittent filtration beds were prepared by Robt. E. Kline, County Engineer, and presented to the State Board of Health, receiving the approval of that body.

The disposal works consists of a screen chamber, collecting reservoir and automatic flush tank, and eight filter beds. The 8-in. outfall sewer empties into a well, fitted with a removable wire basket for the collection of all large matter in the sewage. From this the sewage flows to a covered brick reservoir of 12,000 gallons capacity, from which it is automatically discharged onto the filter beds. After each discharge the reservoir is flushed out by sprinklers placed around the bottom of the same and supplied with water from a 4-in. main leading from the general system. The reservoir is about 150 ft. from the nearest part of the main buildings and the upper end of the filter beds is about 450 ft. further away.

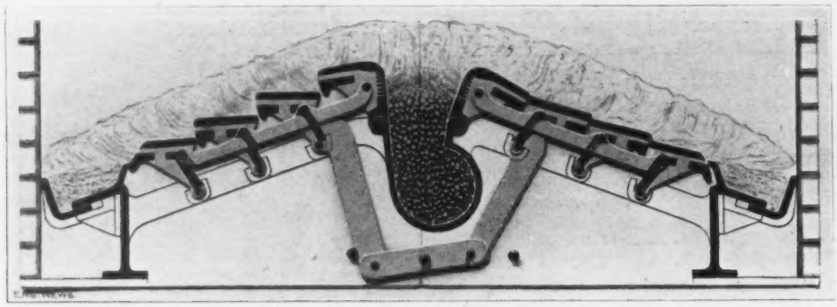


FIG. 1. PAPER MODEL ILLUSTRATING OPERATION OF THE IMPROVED UNDERFEED STOKER.

The beds are each 62.5 × 50 ft. and contain from 3 to 4 ft. of coarse sand and gravel in three layers; the first layer is screened gravel, second, unscreened gravel, and the top layer is sand. The beds are in two rows of four each and are separated from each other by embankments only. The main carrier is in the embankment between the rows. There is a manhole opposite each set of beds from which the discharge onto each bed can be regulated by means of gates. The distributors consist of half tile of four sizes, 6 to 12 ins., laid on top of the gravel, with part of the tile broken away at each reduction in size so as to allow the sewage to flow out on the beds. At each opening in the tile and at the end there is placed a small slab of stone, 4 × 7 ft., bedded in the gravel, on which the sewage first falls from the tile, preventing the sand from being washed away.

The underdrains consist of two lines of 4-in. tile, placed 12.9 ft. from each side of each row of beds and running the full length of the same. These four lines discharge into a 6-in. drain, across the south end of the beds, which, in turn, discharges into a small stream running through the infirmary grounds. The gravel and sand is placed 4 ft. deep over the underdrains and only 3 ft. deep over the space between them, so as to make the rate of filtration more uniform over the entire area.

The daily flow of sewage amounts to a little less than 12,000 gallons, with an increase on Mondays or wash days. This causes the automatic siphon to discharge the sewage from the reservoir each day, the period being shorter in the first part of the week than for the last part. The beds are used in rotation, so each has a rest of seven days before it is used again. The total area of the beds is nearly 0.6-acre and the rate of filtration for the whole area is about 21,000 gallons per acre per 24 hours. Except in times of very wet weather the sewage disappears very quickly from the surface of the beds, and the effluent appears soon after in the underdrains. The day following the use of a bed the surface is raked over and any fibrous matter collected is removed to the fields adjoining. When the filters were first put in, this raking was not done and the beds were allowed to become overgrown with weeds. At first they seemed to do the work without giving any trouble, but they soon became clogged and held the sewage for such a length of time that a nuisance was caused. This trouble was easily overcome by keeping the beds clean, a process requiring only a few hours each day.

As yet no analyses of the sewage and the effluent are available from which the purification secured can be judged, but from the appearance of the effluent the results are satisfactory.

The total cost of the plant complete was $6,097, itemized as follows:

8-in. sewer from buildings to beds	$200
Storage reservoir	132
Siphon	50
Screen well, basket, etc.	85
Water main, sprayers, etc.	655
Manholes and valves	243
Excavating filter beds, 8,000 cu. yds.	800
Stone bulkheads	12
Sand and gravel, 3,900 cu. yds.	3,382
Channel pipe	41
Stone drips	250
Ditch excavation and drain tile	238
Total	$6,097

A NOTABLE IMPROVEMENT IN UNDERFEED STOKERS.

We have received from the Underfeed Stoker Company, Limited, 31 Walbrook, Mansion House, London, E. C., a company organized about two years ago to manufacture the well-known American Underfeed Stoker in Great Britain, a remarkably well-made working card board model, illustrating the operation of movable side-grates which are attached to the stoker. A photographic reproduction of the model is shown in Fig. 1. In the model the horizontal link at the bottom is connected to two levers, operating the grates. On moving the lever to and fro, the movable grates are rocked on their pivots. Each of the movable grates contains a series of tuyeres, which deliver air from the air chamber beneath to the bed of coal lying above. These tuyeres are self-cleaning, the tail of one cleaning the orifice of the other when they are moved by the levers.

Fig. 2 is made from a working drawing of an earlier form of the stoker, but this drawing does not show the combined movable grates and self-cleaning tuyeres that are shown in the model. Coal is fed from the hopper into the trough and upwards out of the trough by means of a long tapering horizontal screw driven by a small steam motor placed in front of the lower part of the hopper. Air, furnished by a fan blower, is fed from the chamber below the trough through tuyeres placed along the upper edges of the trough and also through the tuyeres in the movable grates. Fig. 3 is a half-tone cut of the stoker complete, with its movable grates, a cast-iron wind-box below the grates and a tray outside of the lower grate, which receives the ashes and clinker. Fig. 4 is a sectional view, and Fig. 5 a half-tone showing the application of the underfeed stoker to the furnace flue of a marine internally-fired boiler.

It will be observed from an inspection of the model that the upper portions of the sides of the trough or retort are moved with the tuyere grate bars in such a manner as to break any caked mass of fuel that may be in the coal rising out of the trough. This movement also aids in spreading the fuel. The trough is made narrow, so that the air driven from the orifices into the trough penetrates to the center of the mass of fuel, thoroughly coking it and producing an incandescent bed of fuel. The action of the movable grates forces all the ash or clinker into the trays at the side walls, from which it is removed either through the fire doors or by a dumping arrangement. The improvements in the underfeed stoker above described are due to Mr. W. R. Wood, who was formerly with the American Stoker Co., and who is now engineer of the Underfeed Stoker Co., Limited. They have proven very successful with English coals, and are now being experimented with in this country by the American Stoker Co., No. 11 Broadway, New York; with a view to learn if the improved stoker is better adapted to some varieties of American coals than the stoker now on the market.

REPORT OF THE BOARD OF ENGINEERS, U. S. A., ON THE PROPERTIES AND TESTING OF HYDRAULIC CEMENT.

By an order of Brig.-Gen. John M. Wilson, Chief of Engineers, U. S. Army, issued Dec. 17, 1900, a Board of Engineers, consisting of Maj. W. L. Marshall, Maj. Smith S. Leach, and Capt. Spencer Cosby, U. S. Engineer Corps, was appointed to investigate and report upon the general subject of manipulating and testing hydraulic cements used in the public works carried on under the supervision of the army engineers. This Board submitted its final report under date of June 6, 1901, and it has been printed in No. 28 of the Professional Papers of the Corps of Engineers of the United States Army, which has just been issued from the Government Printing Office. The report covers the subject so concisely and thoroughly and its conclusions are of such general interest to cement users and cement manufacturers that we print it practically in full herewith.

The report opens with a brief statement of the places and dates of the various meetings held by the Board. It then discusses the nature,

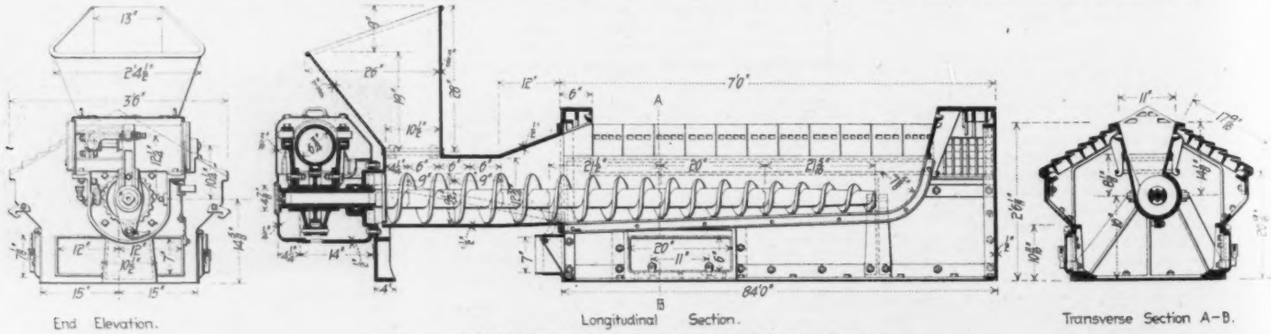


FIG. 2. SECTIONAL VIEWS OF THE AMERICAN STOKER.

tests of a material of known repute. The more elaborate tests, described above, should be made in well-equipped laboratories by skilled cement testers.

CLASSIFICATION OF TESTS.

The tests to be made are two classes: (1) Purchase tests on samples furnished by bidders to ascertain whether the bidder may be held on the sample to the delivery of suitable material, should his offer be accepted. (2) Acceptance tests on samples taken at random from deliveries, to ascertain whether the material supplied accords with the purchase sample, or is suitable for the purpose of the work, as stated in the specifications for cement supplies.

(1) PURCHASE TESTS.—Under these specifications bids for Portland cements will be restricted to brands that have been approved after at least three years' exposure in successful use under similar conditions to those of the proposed work. This specification limits proposals to manufacturers of cements of established repute, and in so far lessens the dependence to be placed upon tests of single samples of cement in determining the probable quality of the cements offered, that sample packages may not be required with the proposals when the brand is known to the purchaser. When the cement is not known to the purchasing officer by previous use, a barrel of it should be required as representing the quality of cement to be supplied. A full set of tests should be made from this sample, and subsequent deliveries be required to show quality at least equal to the sample.

In this connection it is advisable in districts where well-equipped laboratories have been established, that sample packages of the cements in use in that territory, as sold in the open market, be obtained and tested as occasion offers to ascertain the characteristic qualities of the brands as commercial articles, the information to be used in subsequent purchases of cements.

When purchase samples are waived, acceptance tests should be based upon the known qualities of the brand, as shown by previous tests. The sample barrel should not be broken further than to take therefrom the necessary samples for testing. Afterwards it should be put away in a dry place and kept for further testing, should the results obtained be disputed.

(2) ACCEPTANCE TESTS.—The tests to be made on cements delivered under contract depend not only on the extent, character, and importance of the work itself, but also on the time available between the delivery and the actual use of the material.

(a) On very important and extensive works, equipped with a testing laboratory and adequate storehouses, where cement may be kept at least 30 days before being required for use, full and elaborate tests should be made, keeping in view the fact that careful tests of few samples are more valuable than hurried tests of many samples.

(b) On active works of ordinary character, when time will not permit full tests, and on small works where the expenses of a laboratory are not justified, the tests must necessarily be limited to such reasonable precautions against the acceptance and use of unfit material as may be taken in the usually short interval between the receipt and use of the material.

Such conditions were in view in formulating the specification that proposals will be received from manufacturers of such cements only as have been proved by at least three years' use under similar conditions of exposure. Of the tests named in the specifications those for fineness, activity or hydraulicity, specific gravity, weight of packages, and accelerated tests for indications as to soundness, may be made within two days after the receipt of the material and with a very small outlay for instruments.

Cement of established repute, shown by specific gravity and fineness to be properly burnt and ground, or normal for the brand, that will set hard in reasonable time, the cakes snapping with a clean fracture when broken between the fingers, and standing the tests above named, may be accepted and used with reasonably certainty of success. Nevertheless, packages taken at random from the deliveries should occasionally be set aside and samples taken therefrom sent to a testing laboratory for the more elaborate tests for tensile strength (and for soundness should the boiling tests not be conclusive). The final acceptance and payment for such cement as may not have been actually placed in the work should, by agreement, be made to depend upon such tests.

In all cases where cement has been long stored it should be carefully tested before use to ascertain whether it has deteriorated in strength.

Should the simple tests give unsatisfactory or suspicious results, then a full series of tests should be carefully made.

When Portland cement is in question the specific gravity and fineness tests should be made to guard against adulteration, and in all cases test weighings should be made to guard against short weights.

In cases where the amount of cement or the importance of the work will not justify the purchase of the simple apparatus required for the specific gravity, fineness, and boiling tests, the cement can be accepted on the informal tests mentioned herein, which require no apparatus whatever, but in such cases cements well known to the purchaser by previous use should be selected, and purchased directly from the manufacturer or his selling agent in order that responsibility for the cement may be fixed.

Certified tests by professional inspectors made as prescribed herein on samples taken from the cement to be shipped to the work, in a manner analogous to that customary among engineers in the purchase of structural steel and iron, may be required in such cases.

SAMPLING.

The entire package from parts of which tests are to be made is to be regarded as the sample tested. It should be marked with a distinctive mark that must also be applied to any part tested. The package should be set aside and protected against deterioration until all results from tests made from it are reached and accepted by both parties to the contract for supplies.

Cement drawn from several sample packages should not be mixed or mingled, but the individuality of each sample package should be preserved.

In testing it should be borne in mind that a few tests from any sample, carefully made, are more valuable than many made with less care.

The amount of material to be taken for formal tests is indicated herein where weights of the constitutents of four briquettes are given, to which should be added the amount necessary for the tests for specific gravity, activity, and soundness.

In extended tests the material should be taken from the sample package from the heads and center of barrel, and from the ends and center of bag, by such an instrument as is used by inspectors of flour. All material taken from the same sample package may be thoroughly mixed or mingled and the tests be made therefrom as showing the true character of the contents of the sample package.

In making formal tests at the work for acceptance of cement sample packages should be taken at random from among sound packages. The number taken must depend upon the importance and character of the work, the available time, and the capacity of the permanent laboratory force. For tensile strength the tests with sand are considered the more important and should always be made. Tests neat should be made if time permits.

It is not necessary in any case on a large work to test more than 10% of the deliveries, even of doubtful cement, and a much less number of samples may be taken should no cause for distrust be revealed by the tests made. In very important work of small extent each package may be tested. A cement should be rejected if the samples show dangerous variation in quality or lack of care in manufacture and resulting lack of uniformity in the product without regard to the proportion of failures among samples tested.

In all cases in the use of cements the informal or simple tests of the character named herein should be constantly carried on. These constitute most valuable tests. Whenever any faulty material is indicated by such tests, elaborate tests should be at once instituted and should the fault be confirmed, the cement delivered and not used should be rejected and the use of the brand be discontinued.

TESTS FOR WEIGHT.

From time to time packages should be weighed in gross and afterwards the weight of neat cement and tare of the packages determined. If short weight of neat cement is indicated, a sufficient number of packages should be weighed and the average net weight per package ascertained with sufficient certainty to afford a satisfactory basis of settlement.

RECORDS.

For tests of professional laboratories no general requirements as to records seem to be necessary. Each laboratory has its own blanks with certificate, and if a copy of the specifications be sent with the samples, the record returned should be sufficient. For records of formal tests on the work, or in a district laboratory, blank forms should be used. It is desirable to have the specification requirements stated on the form. Notations should be adopted to show for each test that the cement passed or failed or that the test was not made. No inference should be drawn from the lack of any entry other than that the recorder has neglected his duty.

SILICA CEMENT OR SAND CEMENT.

This is a patented article manufactured by grinding together silica or clean sand with Portland cement, by which process the original cementing material is made extremely fine and its capacity to cover surfaces of concrete aggregates is much increased. The sand is an adulteration, but on account of the extreme fineness of the product it serves to make mortar or concrete containing a given proportions of pure cement much more dense, the fine material being increased in volume.

The increase in cementing capacity due to the fine grinding of the cement constituent offsets, in great degree, the effects of the sand adulteration, so that sand cement made from equal weights of cement and sand approximates in tensile strength to the neat cement and the material is sold as cement.

The extreme fine grinding also improves cement that contains expansives, but nevertheless sand cement should not be purchased in the market, but should be made on the work from approved materials, if used for other purposes than for grouting, for which it is peculiarly adapted.

Whether this material should be used in important works for mortar and concrete, the board considers a question of cost and expediency.

Over against the saving in cement may be placed the royalty on a patented article, the cost of the plant and of manufacture, the inconvenience of attaching a manufacturing establishment to a work under construction, and other elements bearing not only on first cost of cementing material but also involving the element of time. When cement is high priced, means of transportation limited, labor, sand, and concrete materials cheap and abundant, the conditions may justify the use of sand cement on economic grounds. In any case, the cement from which the product is made should be tested precisely as other cements.

SLAG CEMENT.

This term is applied to cement made by intimately mixing by grinding together granulated blast-furnace slag of a certain quality and slaked lime, without calcination subsequent to the mixing. This is the only cement of the Puzzolan class to be found in our markets (often branded as Portland), and as true Portland cement is now made having slag for its hydraulic base, the term "slag cement" should be dropped and the generic term Puzzolan be used in advertisements and specifications for such cements.

Puzzolan cement made from slag is characterized physically by its light lilac color; the absence of grit attending fine grinding and the extreme subdivision of its slaked lime element; its low specific gravity (2.6 to 2.8) compared with Portland 3 to 3.5); and by the intense bluish green color in the fresh facture after long submersion in water, due to the presence of sulphides, which color fades after exposure to dry air.

The oxidation of sulphides in dry air is destructive of Puzzolan cement mortars and concretes so exposed. Puzzolan is usually very finely ground, and when not treated with soda sets more slowly than Portland. It stands storage well, but cements treated with soda to quicken setting become again very slow setting from the carbonization of the soda (as well as the lime) element after long storage.

Puzzolan cement properly made contains no free or anhydrous lime, does not warp or swell, but is liable to fail from cracking and shrinking (at the surface only) in dry air.

Mortars and concretes made from Puzzolan approximate in tensile strength similar mixtures of Portland cement, but their resistance to crushing is less, the ratio of crushing to tensile strength being about 6 or 7 to 1 for Puzzolan and 9 to 11 to 1 for Portland. On account of its extreme fine grinding Puzzolan often gives nearly as great tensile strength in 3 to 1 mixtures as neat.

Puzzolan permanently assimilates but little water compared with Portland, its lime being already hydrated. It should be used in comparatively dry mixtures well rammed, but while requiring little water for chemical reactions, it requires for permanency in the air constant or continuous moisture.

PROPER USES OF PUZZOLAN CEMENT.

Puzzolan cement never becomes extremely hard like Portland, but Puzzolan mortars and concrete are tougher or less brittle than Portland. The cement is well adapted for use in sea water, and generally in all positions where constantly exposed to moisture, such as in foundations of buildings, sewers and drains, and underground works generally, and in the interior of heavy masses of masonry or concrete. It is unfit for use when subjected to mechanical wear, attrition, or blows. It should never be used where it may be exposed for long periods to dry air, even after it has well set. It will turn white and disintegrate, due to the oxidation of its sulphides at the surface under such exposure.

SPECIFICATIONS FOR AMERICAN PORTLAND CEMENT.

(1) The cement shall be an American Portland, dry and free from lumps. By a Portland cement is meant the product obtained from the heating or calcining up to incipient fusion of intimate mixtures, either natural or artifical, or argillaceous with calcareous substances, the calcined product to contain at least 1.7 times as much of lime, by weight, as of the materials which give the lime its hydraulic properties, and to be finely pulverized after said calcination, and thereafter additions or substitutions for the purpose only of regulating certain properties of technical importance to be allowable to not exceeding 2% of the calcined product.

(2) The cement shall be put up in strong, sound barrels well lined with paper, so as to be reasonably protected against moisture, or in stout cloth or canvas sacks. Each package shall be plainly labeled with the name of the brand and of the manufacturer. Any package broken or containing damaged cement may be rejected or accepted as a fractional package, at the option of the United States agent in local charge

(3) Bidders will state the brand of cement which they propose to furnish. The right is reserved to reject a tender for any brand which has not established itself as a high-grade Portland cement and has not for three years or more given satisfaction in use under climatic or other conditions of exposure of at least equal severity to those of the work proposed

(4) Tenders will be received only from manufacturers or their authorized agents.

(The following paragraph will be substituted for paragraphs 3 and 4 above when cement is to be furnished and placed by the contractor:

No cement will be allowed to be used except established

taken preferably; it should be constantly applied on the work among other simple tests to be noted, for although the boiling test sometimes rejects suitable material, it is believed that it will always reject a material unsound by reason of the existence of active expansives. Sulphate of lime, while enabling cements to pass the boiling tests, introduces an element of danger.

This test is proposed as suggestive or discriminative only. Except for works of unusual importance it is not recommended that a cement passing the other tests proposed shall be rejected on the boiling test.

TESTS TO BE MADE.

For selecting Portland and Puzzolan cement from among the brands offered, the board recommends that the following tests be made: (1) For fineness of grinding; (2) for specific gravity; (3) for soundness, or constancy of volume in setting; (4) for time of setting; (5) for tensile strength.

For natural cement we recommend the omission of the specific-gravity and soundness tests.

On the works the board recommends simple tests when the more elaborate tests cannot well be made.

In determining the minimum requirements for cements given in the subjoined specifications, we recognize that many cements that attain only fair strength neat and with sand in a short time and show marked gains of strength on further time will fulfill the requirements of the service, and that unusually high tensile strength attained in a few days after gaging is often coupled with a small or negative increase in strength in further short intervals. Unusually high tests in a short time after gaging should be regarded with suspicion, although some well-known brands of American cements show great strength in short-time tests and, so far as observed, are reliable in air and fresh water. Cements offered under such known brands should show their characteristic strength and other qualities or be suspected as spurious or adulterated, if not rejected, even though the minimum requirements of the specifications are met. The practice of offering a bonus or free gift of money in addition to the contract price for cement testing above a fixed high point should be prohibited as unnecessary, for cements so obtained are likely to be unsound in a manner not easily detected in the time usually available in testing.

It is believed that most of the very high testing Portland cements have lime in excess, the effect of which is temporarily masked by the use of sulphate of lime. Over-limed cements so treated are unfit for use in sea water. For such uses a chemical analysis should be required, and the quantity of sulphuric acid, as well as magnesia, be limited to a low percentage. It is not yet known that sulphate of lime in quantity less than 2% is injurious to cements to be used in fresh water or in air. It masks expansives that might ultimately cause the destruction of the work, but it is not known whether this effect is permanent. Its addition is now deemed necessary to control time of setting. It makes a quick-setting cement slow setting, at the same time increasing tensile strength acquired in short time.

MANIPULATION OF CEMENTS FOR TESTS.

FINENESS.—Place 100 parts (denominations determined by subdivisions of the weighing machine used) by weight on a sieve with 100 holes to the linear inch, woven from brass wire No. 40, Stubb's wire gage; sift by hand or mechanical shaker until cement ceases to pass through.

The weight of the material passing the sieve plus the weight of the dust lost in air, expressed in hundredths of the original weight, will express the percentage of fineness. In order to determine this percentage the residue on the sieve should be weighed.

It is only the impalpable dust that possesses cementitious value. Fineness of grinding is therefore an essential quality in cements to be mixed with sand. The residue on a sieve of 100 meshes to the inch is of no cementitious value, and even the grit retained on a sieve of 40,000 openings to the square inch is of small value. The degree of fineness prescribed in these specifications (92%) for Portland through a sieve of 10,000 meshes to the square inch is quite commonly attained in high-grade American cements, but rarely in imported brands. On the Pacific coast, where foreign cements only are in the market, this requirement may be lowered for the present to 87% on No. 100 sieve.

SPECIFIC GRAVITY.—The standard temperature for specific gravity determinations is 62° F., but for cement testing temperatures may vary between 60° and 80° F. without affecting results more than the probable error in the observation. Use any approved form of volumenometer or specific gravity bottle, graduated to cubic centimeters with decimal subdivisions. Fill instrument to zero of the scale with benzine, turpentine, or some other liquid having no action upon cements. Take 100 grams of sifted cement that has been previously dried by exposure on a metal plate for 20 minutes to a dry heat of 212° F., and allow it to pass slowly into the fluid of the volumenometer, taking care that the powder does not stick to the sides of the graduated tube above the fluid and that the funnel through which it is introduced does not touch the fluid. Read carefully the volume of the displaced fluid to the nearest fraction of a cubic centimeter. Then the approximate specific gravity will be represented by 100 divided by the displacement in cubic centimeters. The operation requires care.

SETTING QUALITIES AND SOUNDNESS.—The quantity of water and the temperature of water and air affect the time of setting. The specifications contemplate a temperature varying not more than 10° from 62° F., and quantities of water given herein: For Portland cements use 20% of water; for Puzzolan cements use 18% of water; for natural cements use 30% of water. Mix thoroughly for five minutes, vigorously rubbing the mixture under pressure; time to be estimated from moment of adding water and to be considered of importance.

Make on glass plates two cakes from the mixture about 3 ins. in diameter, ½-in. thick at middle, and drawn to thin edges, and cover them with a damp cloth or place them in a tight box not exposed to currents of dry air. At the end of the time specified for initial set apply the needle 1-12-in. diameter weighted to ¼-lb. to one of the cakes. If an indentation is made the cement passes the requirement for initial setting, if no indentation is made by the needle it is too quick setting. At the end of the time specified for "final set" apply the needle 1-24-in. diameter loaded to 1 lb. The cement cake should not be indented.

Expose the two cakes to air under damp cloth for 24 hours. Place one of the cakes, still attached to its plate, in water for 28 days; the other cake immerse in water at about 70° temperature supported in a rack above the bottom of the receptacle; raise the water gradually to the boiling point and maintain this temperature for six hours and then let the water with cake immersed cool. Examine the cakes at the proper time for evidences of expansion and distortion. Should the boiled cake become detached from the plate by twisting and warping or show expansion cracks the cement may be rejected, or it may await the result of 28 days in water. If the fresh-water cake shows no evidences of swelling, the cement may be used in ordinary work in air or fresh water for lean mixtures. If distortion or expansion cracks are shown on the fresh-water cake, the cement should be rejected. Of two or more cements offered, all of which will stand the fresh-water cake tests for soundness, the cements that will stand the boiling tests also are to be preferred.

TENSILE STRENGTH.—Neat tests: Use unsifted cements. Place the amount to be mixed on a smooth, non-absorbent slab; make a crater in the middle sufficient to hold the water; add nearly all the water at once, the remainder as needed; mix thoroughly by turning with the trowel, and vigorously rub or work the cement for five minutes.

Place the mold on a glass or slate slab. Fill the mold with consecutive layers of cement, each when rammed to be ¼-in. thick. Tap each layer 30 taps with a soft brass or copper rammer weighing 1 lb. and having a face ¾-in. diameter or 7-10-in. square with rounded corners. The tapping or ramming is to be done as follows: while holding the forearm and wrist at a constant level, raise the rammer with the thumb and forefinger about ½-in. and then let it fall freely, repeating the operation until the layer is uniformly compacted by 30 taps.

This method is intended to compact the material in a manner similar to actual practice in construction, when a metal rammer is used weighing 30 lbs., with a circular head 5 ins. in diameter falling about 8 ins. upon layers of mortar or concrete 3 ins. thick. The method permits comparable results to be obtained by different observers.

After filling the mold and ramming the last layer, strike smooth with the trowel, tap the mold lightly in a direction parallel to the base plate to prevent adhesion to the plate, and cover for 24 hours with a damp cloth. Then remove the briquette from the mold and immerse it in fresh water, which should be renewed twice a week for the specified time if running water is not available for a slow current. If molds are not available for 24 hours, remove from the molds after final set, replacing the damp cloth over the briquettes. In removing briquettes before hard-set great care should be exercised. Hold the mold in the left hand and, after loosening the latch, tap gently the sides of the mold until they fall apart. Place the briquettes face down in the water trough.

For neat tests of Portland cement use 20% of water by weight. For neat tests of Puzzolan cement use 18% of water by weight. For neat tests of natural cement use 30% of water by weight. Nearly all this water is retained by Portland cement, whereas only about one-third of the gaging water is retained by Puzzolan or natural cements; from this it follows that an apparent condition of plasticity or fluidity that ultimately little injures Portland paste, very seriously injures Puzzolan or natural mortars and concretes by leaving a porous texture on the evaporation of the surplus water.

Sand tests: The proportions 1 cement to 3 sand are to be used in tests of Puzzolan and Portland, and 1 cement to 1 sand in tests of natural or Rosendale cements. Crushed quartz sand, sifted to pass a standard sieve with 20 meshes per lin. in. and to be retained on a standard sieve with 30 meshes to the inch, is to be used.

After weighing carefully, mix dry the cement and sand until the mixture is uniform, add the water as in neat mixtures, and mix for five minutes by triturating or rubbing together the constituents of the mortar. This may be done under pressure with a trowel or by rubbing between the fingers, using rubber gloves. The rubbing together seems necessary to coat thoroughly the facets of the sand with the cement paste.

It is found that prolonged rubbing, when carried beyond the time of initial set, results in better tests. Five minutes is the time of mixing quite generally adopted in European specifications. The briquettes are to be made as prescribed for neat mixtures.

Portland cements require water from 11 to 12% by weight of constituent sand and cement for maximum strength in tested briquettes; Puzzolan, about 10%, and natural, about 15 to 17%. Mixtures that appear too dry for testing purposes often become more plastic under the prolonged working required by this method.

In general, about four briquettes constitute the maximum number that may be made well within the time required for initial setting of moderately slow-setting cements. Three such batches of sand mixtures should be made, and one briquette of each batch may be broken at seven and 28 days, giving three tests at each period. At least one batch of neat cement briquettes should be made.

If the first briquette broken at each date fulfils the minimum requirement of these specifications it is not necessary to break others which may be reserved for long-time tests. If the first briquette does not pass the test for tensile strength, then briquettes may be broken until six briquettes, two from each batch, have been broken at seven days, and the remaining six reserved for 28-day tests. The highest result from any sample is to be taken as the strength of the sample when the break is at the least section of briquette.

If, on the 28-day tests, the cement not only more than fulfills the minimum requirements of these specifications, but also shows unusual gain in strength, it may still be accepted if the other tests are satisfactory, notwithstanding a low seven-day test, if early strength is not a matter of importance. Such cements are likely to be permanent.

For a batch of four briquettes, the following quantities are suggested as in accord with these specifications. Water is measured by fluid-ounce volumes, not by weight, temperature varying not more than 10° from 62° F.

Portland Cement.

Neat: 20 ozs. of cement, 4 ozs. of water. Mix wet five minutes.

Sand: 15 ozs. sand, 5 ozs. cement, 2½ ozs. water. Mix thoroughly dry; then mix wet five minutes.

Puzzolan Cement.

Neat: 20 ozs. cement, 3¾ ozs. water. Mix wet five minutes.

Sand: 15 ozs. sand, 5 ozs. cement, 2 ozs. water. Mix thoroughly dry; then mix wet five minutes.

Natural Cement.

Neat: 20 ozs. cement, 6 ozs. water. Mix wet five minutes.

Sand: 10 ozs. cement, 10 ozs. sand, 3½ ozs. water. Mix dry; then wet for five minutes.

For measuring tensile strength, a machine that applies the stress automatically at a uniform rate is preferable to one controlled entirely by hand. These specifications for tensile strength contemplate the application of stress at the rate of 400 lbs. per minute to briquettes made as prescribed herein. A rate so rapid as to approximate a blow or so slow as to approximate a continued stress will give very different results.

The tests for tensile strength are to be made immediately after taking from the water or while the briquettes are still wet. The temperature of the water during immersion should be maintained as nearly constant as practicable; not less than 50° nor more than 70° F.

The tests are to be made upon briquettes 1 in. sq. at place of rupture. The specifications contemplate the use of the form of briquette recommended by the committee of the American Society of Civil Engineers, held when tested by close-fitting metal clips, without rubber or other yielding contacts. The breaks considered in the tests are to be those occurring at the smallest section, 1 in. sq.

SIMPLE TESTS.

Tests of cement received upon a work in progress must often be of much simpler character than prescribed herein. Tests on the work are mainly to ascertain whether the article supplied is genuine cement, of a brand previously tested and accepted, and whether it is a reasonably sound and active cement that will set hard in the desired time, and give a good, hard mortar. Simple tests may give this information, and such should be multiplied whether or not more elaborate tests be made. Pats and balls of cement and mortar from the storehouse and mixing platform or machine should be frequently made. The setting or hardening qualities, as determined roughly by estimating time and by pressure of the thumbnail, should be observed; the hardness of the set and strength, by crackening the hardened pats or cakes between the fingers, and by dropping the balls from the height of the arm upon a pavement or stone and observing the result of the impact.

By placing the pats in water as soon as hardened sufficiently and raising the temperature to the boiling point for a few hours and observing the character and color of the fracture after sufficient immersion, information as to the character of the material, whether hydraulic, a Portland or Puzzolan, whether too fresh or possibly "blowy," may be speedily and quite well ascertained without measuring instruments.

Many engineers and users of cements regard such simple tests, taken in connection with the weight and fineness of the cement and the apparent texture and hardness of the mortars and concretes in the work, sufficient field

brands of high-grade Portland cement which have been made by the same mill and in successful use under similar climatic conditions to those of the proposed work for at least three years.)

(5) The average weight per barrel shall not be less than 375 lbs. net. Four sacks shall contain one barrel of cement. If the weight, as determined by test weighings, is found to be below 375 lbs. per barrel, the cement may be rejected, or, at the option of the engineer officer in charge, the contractor may be required to supply, free of cost to the United States, an additional amount of cement equal to the shortage.

(6) Tests may be made of the fineness, specific gravity, roundness, time of setting, and tensile strength of the cement.

(7) FINENESS.—Ninety-two per cent. of the cement must pass through a sieve made of No. 40 wire, Stubb's gage, having 10,000 openings per sq. in.

(8) SPECIFIC GRAVITY.—The specific gravity of the cement, as determined from a sample which has been carefully dried, shall be between 3.10 and 3.25.

(9) SOUNDNESS.—To test the soundness of the cement, at least two pats of neat cement mixed for five minutes with 20% of water by weight shall be made on glass, each pat about 3 ins. in diameter and ½-in. thick at the center, tapering thence to a thin edge. The pats are to be kept under a wet cloth until finally set, when one is to be placed in fresh water for 28 days. The second pat will be placed in water which will be raised to the boiling point for six hours, then allowed to cool. Neither should show distortion or cracks. The boiling test may or may not reject at the option of the engineer officer in charge.

(10) TIME OF SETTING.—The cement shall not acquire its initial set in less than 45 mins. and must have acquired its final set in 10 hours.

(The following paragraph will be substituted for the above in case a quick-setting cement is desired:

The cement shall not acquire its initial set in less than 20 nor more than 30 mins., and must have acquired its final set in not less than 45 mins. nor in more than 2½ hours.)

The pats made to test the soundness may be used in determining the time of setting. The cement is considered to have acquired its initial set when the pat will bear, without being appreciably indented, a wire 1-12-in. in diameter loaded to weigh ¼-lb. The final set has been acquired when the pat will bear, without being appreciably indented, a wire 1-24-in. in diameter loaded to weigh 1 lb.

(11) TENSILE STRENGTH.—Briquettes made of neat cement, after being kept in air for 24 hours under a wet cloth and the balance of the time in water, shall develop tensile strength per square inch as follows: After seven days, 450 lbs.; after 28 days, 540 lbs.

Briquettes made of 1 part cement and 3 parts standard sand, by weight, shall develop tensile strength per square inch as follows: After seven days, 140 lbs.; after 28 days, 220 lbs.

(In case quick-setting cement is desired, the following tensile strengths shall be substituted for the above: Neat briquettes: After seven days, 400 lbs.; after 28 days, 480 lbs. Briquettes of 1 part cement to 3 parts standard sand: After seven days, 120 lbs.; after 28 days, 180 lbs.)

(12) The highest result from each set of briquetes made at any one time is to be considered the governing test. Any cement not showing an increase of strength in the 28-day tests over the seven-day tests will be rejected.

(13) When making briquettes neat cement will be mixed with 20% of water by weight, and sand and cement with 12½% of water by weight. After being thoroughly mixed and worked for five minutes, the cement or mortar will be placed in the briquette mold in four equal layers, and each layer rammed and compressed by 30 blows of a soft brass or copper rammer ¾-in. in diameter (or 7-10-in. square, with rounded corners), weighing 1 lb. It is to be allowed to drop on the mixture from a height of about ½-in. When the ramming has been completed, the surplus cement shall be struck off and the final layer smoothed with a trowel held almost horizontal and drawn back with sufficient pressure to make its edge follow the surface of the mold.

(14) The above are to be considered the minimum requirements. Unless a cement has been recently used on work under this office, bidders will deliver a sample barrel for test before the opening of bids. If this sample shows higher tests than those given above, the average of tests made on subsequent shipments must come up to those found with the sample.

(15) A cement may be rejected in case it fails to meet any of the above requirements. An agent of the contractor may be present at the making of the tests, or, in case of the failure of any of them, they may be repeated in his presence. If the contractor so desires, the engineer officer in charge may, if he deem it to the interest of the Unitd States, have any or all of the tests made or repeated at some recognized standard testing laboratory in the manner herein specified. All expenses of such tests to be paid by the contractor. All such tests shall be made on samples furnished by the engineer officer from cement actually delivered to him.

SPECIFICATIONS FOR NATURAL CEMENT.

(1) The cement shall be a freshly packed natural or Rosendale, dry, and free from lumps. By natural cement is meant one made by calcining natural rock at a heat below incipient fusion, and grinding the product to powder.

(2) The cement shall be put up in strong, sound barrels, well lined with paper so as to be reasonably protected against moisture, or in stout cloth or canvas sacks. Each package shall be plainly labeled with the name of the brand and of the manufacturer. Any package broken or containing damaged cement may be rejected, or accepted as a fractional package, at the option of the United States agent in local charge.

(3) Bidders will state the brand of cement which they propose to furnish. The right is reserved to reject a tender for any brand which has not given satisfaction in use under climatic or other conditions of exposure of at least equal severity to those of the work proposed.

(4) Tenders will be received only from manufacturers or their authorized agents.

(The following paragraph will be substituted for paragraphs 3 and 4 above when cement is to be furnished and placed by the contractor:

No cement will be allowed to be used except established brands of high-grade natural cement which have been in successful use under similar climatic condtions to those of the proposed work.)

(5) The average net weight per barrel shall not be less than 300 lbs. (West of the Allegheny Mountains this may be 265 lbs.) . . . sacks of cement shall have the same weight as 1 barrel. If the average net weight, as determined by test weighings, is found to be below 300 lbs. (265 lbs.) per barrel, the cement may be rejected, or, at the option of the engineer officer in charge, the contractor may be required to supply free of cost to the United States an additional amount of cement equal to the shortage.

(6) Tests may be made of the fineness, time of setting, and tensile strength of the cement.

(7) FINENESS.—At least 80% of the cement must pass through a sieve made of No. 40 wire, Stubb's gage, having 10,000 openings per sq. in.

(8) TIME OF SETTING.—The cement shall not acquire its initial set in less than 20 mins. and must have acquired its final set in 4 hrs.

(9) The time of setting is to be determined from a pat of neat cement mixed for five minutes with 30% of water by weight and kept under a wet cloth until finally set. The cement is considered to have acquired its initial set when the pat will bear, without being appreciably indented, a wire 1-12-in. in diameter loaded to weigh ¼-lb. The final set has been acquired when the pat will bear, without being appreciably indented, a wire 1-24-in. in diameter loaded to weigh 1 lb.

(10) TENSILE STRENGTH.—Briquettes made of neat cement shall develop the following tensile strengths per square inch, after having been kept in air for 24 hrs. under a wet cloth and the balance of the time in water: At the end of seven days, 90 lbs.; at the end of 28 days, 200 lbs. Briquettes made of one part cement and one part standard sand by weight shall develop the following tensile strengths per square inch: After seven days, 60 lbs.; after 28 days, 150 lbs.

(11) The highest result from each set of briquettes made at any one time is to be considered the governing test. Any cement not showing an increase of strength in the 28-day tests over the seven-day tests will be rejected.

(12) The neat cement for briquettes shall be mixed with 30% of water by weight, and the sand and cement with 17% of water by weight. After being thoroughly mixed and worked for five minutes the cement or mortar is to be placed in the briquette mold in four equal layers, each of which is to be rammed and compressed by 30 blows of a soft brass or copper rammer ¾-in. in diameter (or 7-10-in. square with rounded corners), weighing 1 lb. It is to be allowed to drop on the mixture from a height of about ½-in. Upon the completion of the ramming the surplus cement shall be struck off and the last layer smoothed with a trowel held nearly horizontal and drawn back with sufficient pressure to make its edge follow the surface of the mold.

(13) The above are to be considered the minimum requirements. Unless a cement has been recently used on work under this office, bidders will deliver a sample barrel for test before the opening of the bids. Any cement showing by sample, higher tests than those given must maintain the average so shown in subsequent deliveries.

(14) A cement may be rejected which fails to meet any of the above requirements. An agent of the contractor may be present at the making of the tests, or, in case of the failure of any of them, they may be repeated in his presence. If the contractor so desires, the engineer officer may, if he deems it to the interest of the United States, have any or all of the tests made or repeated at some recognized standard testing laboratory in the manner above specified. All expenses of such tests shall be paid by the contractor, and all such tests shall be made on samples furnished by the engineer officer from cement actually delivered to him.

SPECIFICATIONS FOR PUZZOLAN CEMENT.

(1) The cement shall be a Puzzolan of uniform quality, finely and freshly ground, dry, and free from lumps, made by grinding together without subsequent calcination granulated blast-furnace slag with slaked lime.

(2) The cement shall be put up in strong sound barrels well lined with paper, so as to be reasonably protected against moisture, or in stout cloth or canvas sacks. Each package shall be plainly labeled with the name of the brand and of the manufacturer. Any package broken or containing damaged cement may be rejected, or accepted as a fractional package, at the option of the United States agent in local charge.

(3) Bidders will state the brand of cement which they propose to furnish. The right is reserved to reject a tender for any brand which has not given satisfaction in use under climatic or other conditions of exposure of at least equal severity to those of the work proposed, and for any brand from cement works that do not make and test the slag used in the cement.

(4) Tenders will be received only from manufacturers or their authorized agents.

(The following paragraph will be substituted for paragraphs 3 and 4 above when cement is to be furnished and placed by the contractor:

No cement will be allowed to be used except established brands of high-grade Puzzolan cement which have been in successful use under similar climatic conditions to those of the proposed work and which come from cement works that make the slag used in the cement.)

(5) The average weight per barrel shall not be less than 330 lbs. net. Four sacks shall contain 1 barrel of cement. If the weight as determined by test weighings is found to be below 330 lbs. per barrel, the cement may be rejected, or, at the option of the engineer officer in charge, the contractor may be required to supply, free of cost to the United States, an additional amount of cement equal to the shortage.

(6) Tests may be made of the fineness, specific gravity, soundness, time of setting, and tensile strength of the cement.

(7) FINENESS.—Ninety-seven per cent. of the cement must pass through a sieve made of No. 40 wire, Stubb's gage, having 10,000 openings per sq. in.

(8) SPECIFIC GRAVITY.—The specific gravity of the cement, as determined from a sample which has been carefully dried, shall be between 2.7 and 2.8.

(9) SOUNDNESS.—To test the soundness of cement, pats of neat cement mixed for five minutes with 18% of water by weight shall be made on glass, each pat about 3 ins. in diameter and ½-in. thick at the center, tapering thence to a thin edge. The pats are to be kept under wet cloths until finally set, when they are to be placed in fresh water. They should not show distortion or cracks at the end of 28 days.

(10) TIME OF SETTING.—The cement shall not acquire its initial set in less than 45 mins. and shall acquire its final set in 10 hrs. The pats made to test the soundness may be used in determining the time of setting. The cement is considered to have acquired its initial set when the pat will bear, without being appreciably indented, a wire 1-12-in. in diameter loaded to ¼-lb. weight. The final set has been acquired when the pat will bear, without being appreciably indented, a wire 1-24-in. in diameter loaded to 1 lb. weight.

(11) TENSILE STRENGTH.—Briquettes made of neat cement, after being kept in air under a wet cloth for 24 hrs. and the balance of the time in water, shall develop tensile strength per sq. in. as follows: After seven days, 350 lbs.; after 28 days, 500 lbs. Briquettes made of one part cement and three parts standard sand by weight shall develop tensile strength per sq. in. as follows: After seven days, 140 lbs.; after 28 days, 220 lbs.

(12) The highest result from each set of briquettes made at any one time is to be considered the governing test. Any cement not showing an increase of strength in the 28-day tests over the seven-day tests will be rejected.

(13) When making briquettes neat cement will be mixed with 18% of water by weight, and sand and cement with 10% of water by weight. After being thoroughly mixed and worked for five minutes the cement or mortar will be placed in the briquette mold in four equal layers and each layer rammed and compressed by 30 blows of a soft brass or copper rammer, ¾-in. in diameter or 7-10-in. square, with rounded corners, weighing 1 lb. It is to be allowed to drop on the mixture from a height of about ½-in. When the ramming has been completed the surplus cement shall be struck off and the final layer smoothed with a trowel held almost horizontal and drawn back with sufficient pressure to make its edge follow the surface of the mold.

(14) The above are to be considered the minimum requirements. Unless a cement has been recently used on work under this office, bidders will deliver a sample barrel for test before the opening of bids. If this sample shows higher tests than those given above, the average of tests made on subsequent shipments must come up to those found with the sample.

(15) A cement may be rejected in case it fails to meet any of the above requirements. An agent of the contractor may be present at the making of the tests, or, in case of the failure of any of them, they may be repeated in his presence. If the contractor so desires the engineer officer in charge may, if he deems it to the interest of the United States, have any or all of the tests made or repeated at some recognized testing laboratory in the manner herein specified, all expenses of such tests to be paid by the contractor. All such tests shall be made on samples furnished by the engineer officer from cement actually delivered to him.